POWER

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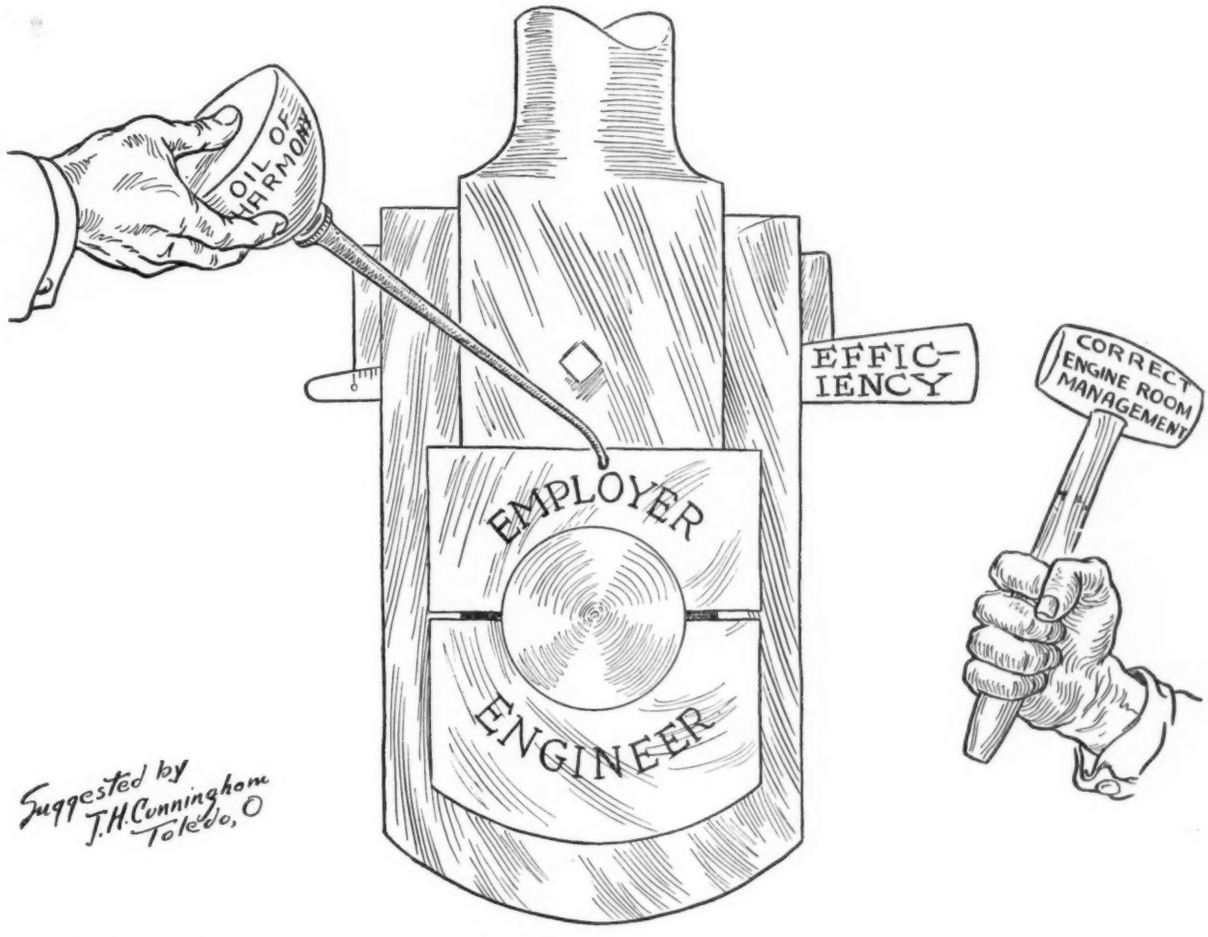


A Smooth Running Bearing

Plant of Dime Savings Bank Building, Detroit

By Thomas Wilson

SYNOPSIS—This is a model plant of 1000-kw. capacity designed to serve two office buildings. The older building has been taking central-station heat, light power and refrigeration. The plant in the new building will effect a large saving.

The largest office building in Michigan was recently erected at the corner of Griswold and Fort Sts., Detroit, by Edward Ford, of Toledo, Ohio. It is a handsome structure, 23 stories high, with two basements, and is built in the form of an "H" on a plot measuring 130x 150 ft. The first floor is given over to the bank and a

Fig. 1. Dime Savings Bank Building, Detroit, Mich.

number of stores, and those above to 858 office suites, housing about 3000 people. The building, which appears in Fig. 1, is equipped with the latest services and has its own plant to furnish current for lighting, power and elevators, steam for heating, hot water for house use, refrigeration and vacuum cleaning. The Ford Building, another property under the same ownership, will also be served by the new plant. The two buildings are connected by a 7x7-ft. tunnel 500 ft. long, so that there will be no difficulty in carrying the mains and cables necessary to the older building. It has been supplied with electrical energy, steam and enough refrigeration to cool the drinking water by a public-service corporation and will continue to take these services until the contract expires two years hence. As a consequence, the new plant is underloaded for the time being and is not

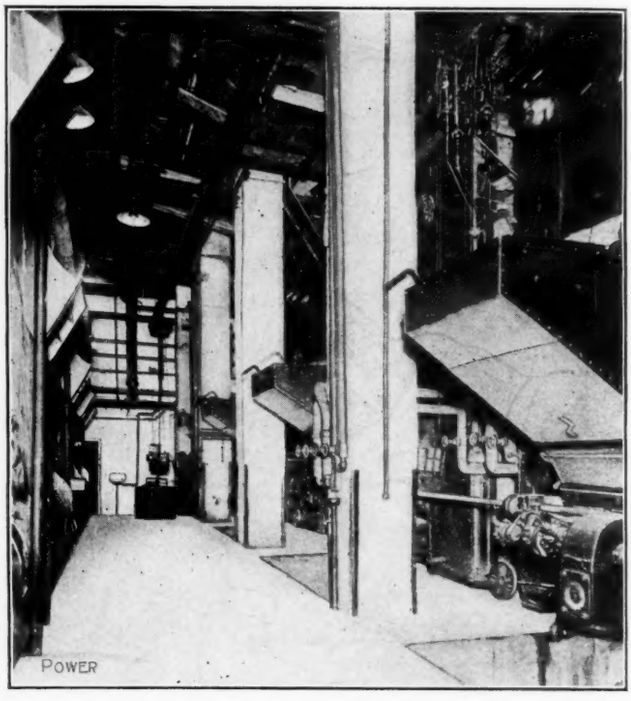


Fig. 2. Boiler Fronts and Coal Bunker at Left

giving quite as good results as it will when carrying both buildings.

Services Rendered by Plant

The Dime Savings Bank Building is equipped with 3400 sixty-watt lights, which total 204 kw. when all are in use. The power load consists of 29 motors for general use ranging from 3 to 60 hp., and nine elevator motors, eight of 25- and one of 30-hp. capacity. These high-speed, direct-traction motors take current at 220 volts. The car speed is 550 ft. per min. and the direct travel 268 ft. In February, the electrical load averaged close to 2200 kw.-hr. per day of 24 hr., which would call for a uniform generator capacity of less than 100 kw. The night and Sunday loads, however, are light, and during week days, when the elevators frequently impose heavy peaks, it is necessary to keep two 200-kw. units in operation, although for the greater part of the time one machine could handle the load.

For heating the building there are 47,000 sq.ft. of direct radiation and 16,000 of indirect serving the bank and a restaurant in the first basement. As much as possible of this is made up by the exhaust from the main units and the steam-driven auxiliaries. The balance is

live steam supplied direct from the boilers through a reducing valve. Besides, live steam is supplied to the restaurant at 30-lb. and some at 6-lb. pressure to a 30-ton absorption plant to supplement the exhaust from the brine, aqua and drinking-water pumps.

In the Ford Building, which is 19 stories high and in plan measures 138x110 ft., there is a total connected motor load of 426 hp. besides the lighting. For an average the year around, the load will closely approximate that of the new building. Most of the power is required by the six hydraulic plunger elevators which have a travel of 212 ft.; during the day they are served by a 9x18-in. triplex pump driven by a 150-hp. motor. There are two other pumps, each 7½x12 in., of the same type, driven by 80-hp. motors, which are used singly for night service or in unison when the large pump is shut down. Besides, one of the smaller pumps is carried on the line continuously, but is set low so that it is not called into service unless something serious happens to the main pump and fan rooms are in the first basement and the boiler room occupies a part of both. There is a total capacity of 1400 hp. in boilers, 1000 kw. in five generating units (a ratio of 1.4 to 1, respectively) and a refrigerating capacity of 30 tons. About half of the auxiliaries are steam driven and the balance is operated by motors. The electrical service is three-wire, direct-current.

Boiler Rooom

There are four water-tube boilers, see Fig. 2, each rated at 350 hp., which have 3500 sq.ft. of heating surface. The working pressure is 150 lb., with no superheat. Each boiler is equipped with a Taylor stoker of the three-retort type, and all but one have ignition arches. The exception apparently steams harder, but there has been no noticeable difference in the economy. Farmington, W. Va., coal having 13,800 B.t.u. and costing $2.75 per ton, is the fuel burned. A fuel bed averaging 30 in. is carried, and forced draft is supplied by

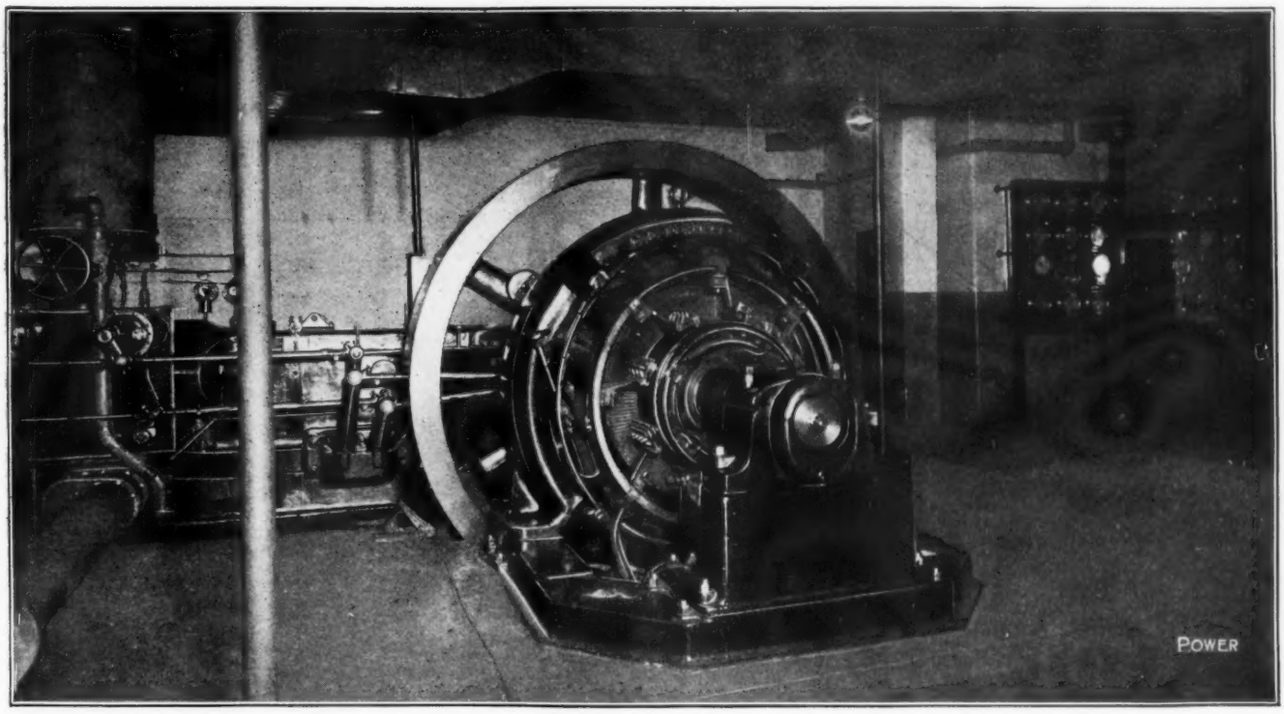


Fig. 3. One of the Generating Units and the Gage Board

unit. The pumps operate against an average pressure of 180 lb. and are set to cut out at 220 lb. There is also a triplex 5½x12-in. pump driven by a 25-hp. motor which serves a four-ton freight lift. For ventilating and exhaust fans there are six motors totaling 50 hp. Two house pumps and the ice-water circulating pump are each driven by 4-hp. motors, two circulating pumps on the air washers take 2 hp. each, the vacuum cleaner 15 hp.; for the sewage ejector there are duplicate sets of air compressors driven by 5-hp. motors.

The building has 38,000 sq.ft. of direct radiation served by a Paul system, which is now supplied with steam at 5-lb. pressure by the Murphy Power Co. To maintain the hot-water service, steam is required all the year round.

In the Dime Savings Bank Building the engine room is in the sub-basement, 32 ft. below the street level, the either of two 60-hp. motor-driven fans with a capacity of 36,000 cu.ft. of air per min. At the wind boxes of the stoker the air pressure is 3 in. of water.

The breeching is rectangular in section, at the farthest boiler the dimensions being 4 ft. 4 in. by 4 ft., at the second boiler, 4 ft. 4 in. by 6 ft. 5 in., and at the fourth boiler and from there on to the stack, 4 ft. 4 in. by 9 ft. 6 in. Three sweeping turns intervene between the boilers and the stack, but as the latter rises 370 ft. above the grates and gives a theoretical draft of nearly 2.5 in. at 500 deg., the added resistance to the flow of gases is easily cared for. As a matter of fact, it is necessary to damper the pull of the stack to a small fraction of an inch over the fire, as the blower forces the air through the fuel bed and it is only necessary for the stack to overcome the resistance to the flow of gas in the settings and breeching. The stack is oval in section.

measuring 4 ft. 10 in. by 9 ft., and is lined all the way up with 2½-in. vitrified asbestos. The entire load is now carried by one boiler which, during the winter, is run at 40 per cent. overload, in the spring and fall at rating, and in the summer it is underloaded.

Feed water is drawn from a 1500-hp. open heater by either of two outside end packed plunger pot-valve

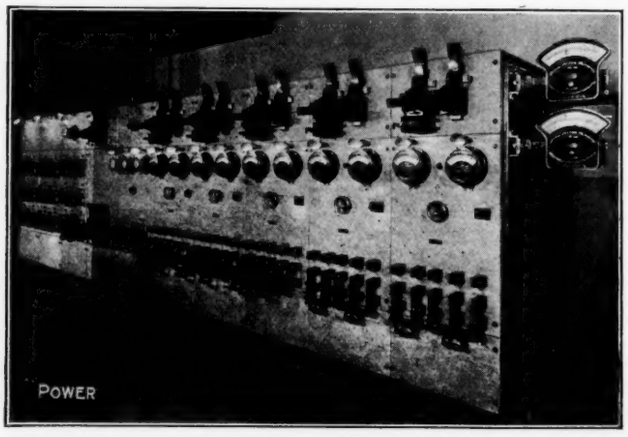


Fig. 4. Ten-Panel Switchboard

pumps, 7½ and 5 by 10 in., which have duplicate steam lines, one from each header. The water lines are also in duplicate. Two 2-in. injectors are installed as a reserve. The water is measured by a venturi meter and there is a second meter to measure the drips which are returned by means of a Holly system.

Coal and Ash Handling

Coal is delivered by wagon and dumped directly into a bunker 9 ft. 2 in. wide, 56 ft. long and 32 ft. deep. There are three manholes and four doors on the boiler-room side of the bunker near the bottom, the latter being equipped with gates and short chutes through which the coal is loaded into a traveling monorail bucket of 900-lb. capacity, fitted with a suspended type of scale.

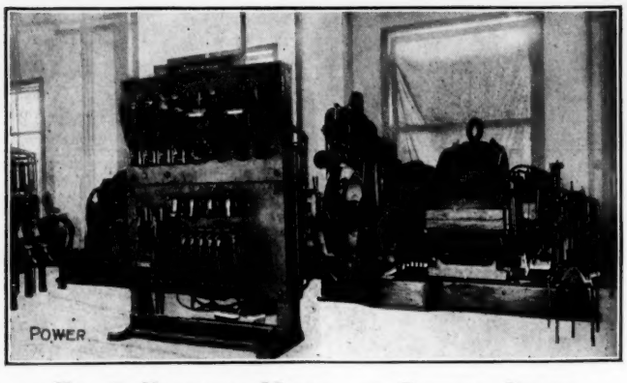


Fig. 5. Elevator Motor and Control Board

The bucket may be raised or lowered by an electric hoist. The stoker hoppers have been enlarged to hold four buckets of coal about 3600 lb., at a time, and at the outer edge have hooks which catch the bucket and cause it to tilt its contents into the hopper.

For removing ashes the same bucket is lowered into the ashpit which extends past the boiler front. The ashes are shoveled in and then carried to a bucket elevator at the end of the boiler room.

Engine Room

There are five generating units rated at 200 kw. The engines are 17x27-in. and of the four-valve, nonreleasing type provided with 10-ton flywheels and revolving at 150 r.p.m. Fig. 3, shows one of the units. The generators are three-wire, 115-230-volt direct-connected machines and designed to adjust an unbalancing of 200 amp. per side. The engine cylinders are oiled by force-feed lubricators. Oil from the bearings is passed through filters once a week and returned to the four-barrel storage tank near the engine-room ceiling to give a gravity flow to the bearings.

The switchboard, Fig. 4, has ten panels of blue Vermont marble, five for generators, one tie panel, and four feeder panels. There are two sets of busbars, one for power and one for light, and when necessary the two can be thrown together at the tie panel. Two integrating meters record the lighting load, one the total output and another the supply to the elevators. There is also a gage board showing pressures on the various boilers and

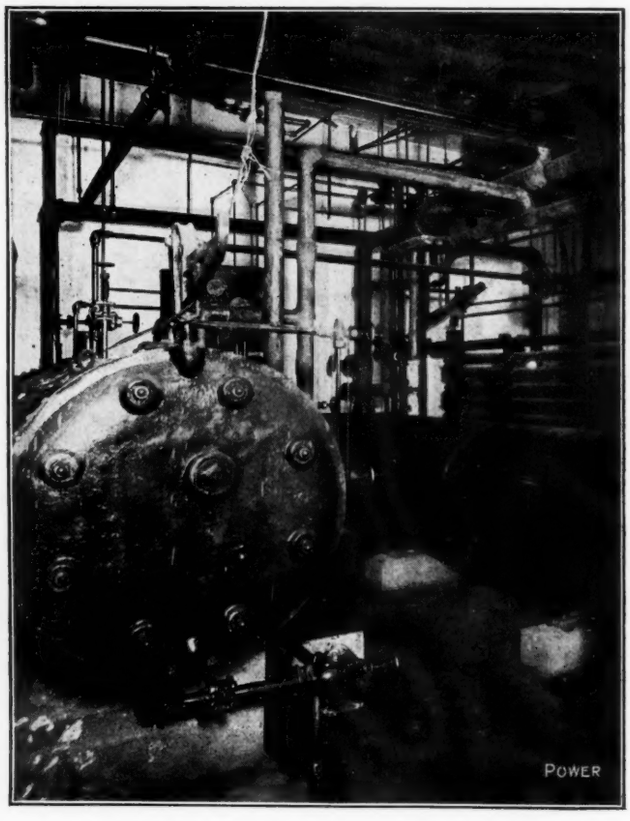


Fig. 6. Part of the Absorption Plant

headers, the city water and heating mains and the air compressor. On the steam services there are also recording gages, and a differential draft gage shows the pressure in the breeching.

Piping

As shown in the plan of the piping, Fig. 7, 8-in. leads extend from the middle drum of each boiler through automatic stop and non-return valves to a 12-in. steel header. Horizontal bends of 7-ft. radius care for the expansion and contraction. The header has a valve at the center and one at either end, so that any one of the boilers may feed in either direction, an 8-in. loop making the circuit of the engine room. Six-inch pipes supply

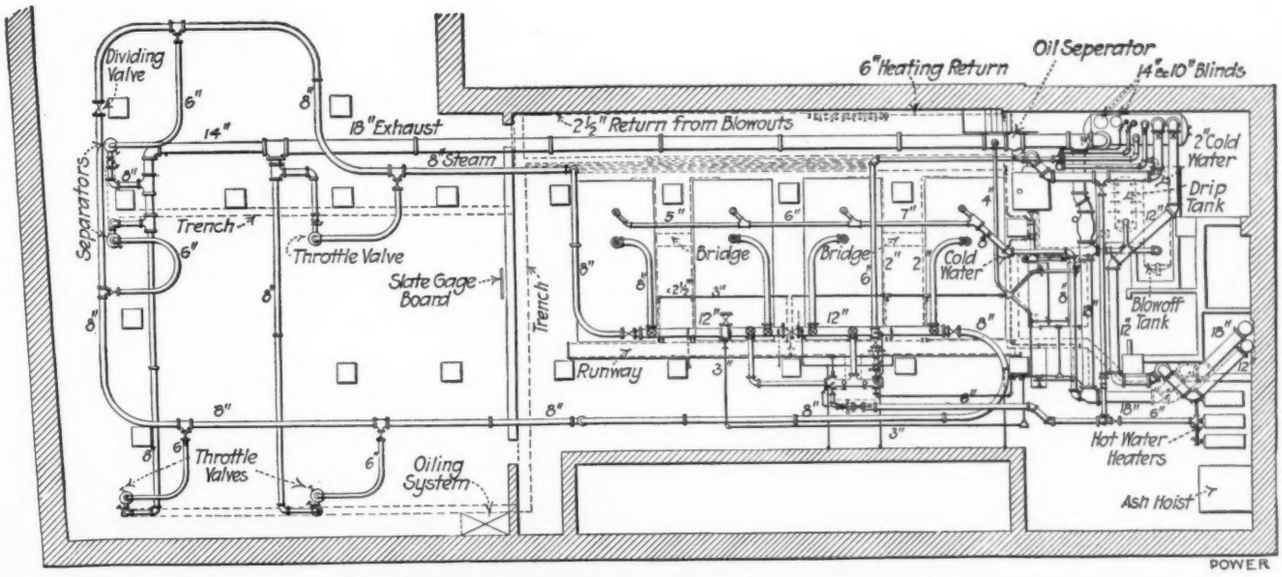


FIG. 7. PLAN OF PIPING IN ENGINE AND BOILER ROOMS

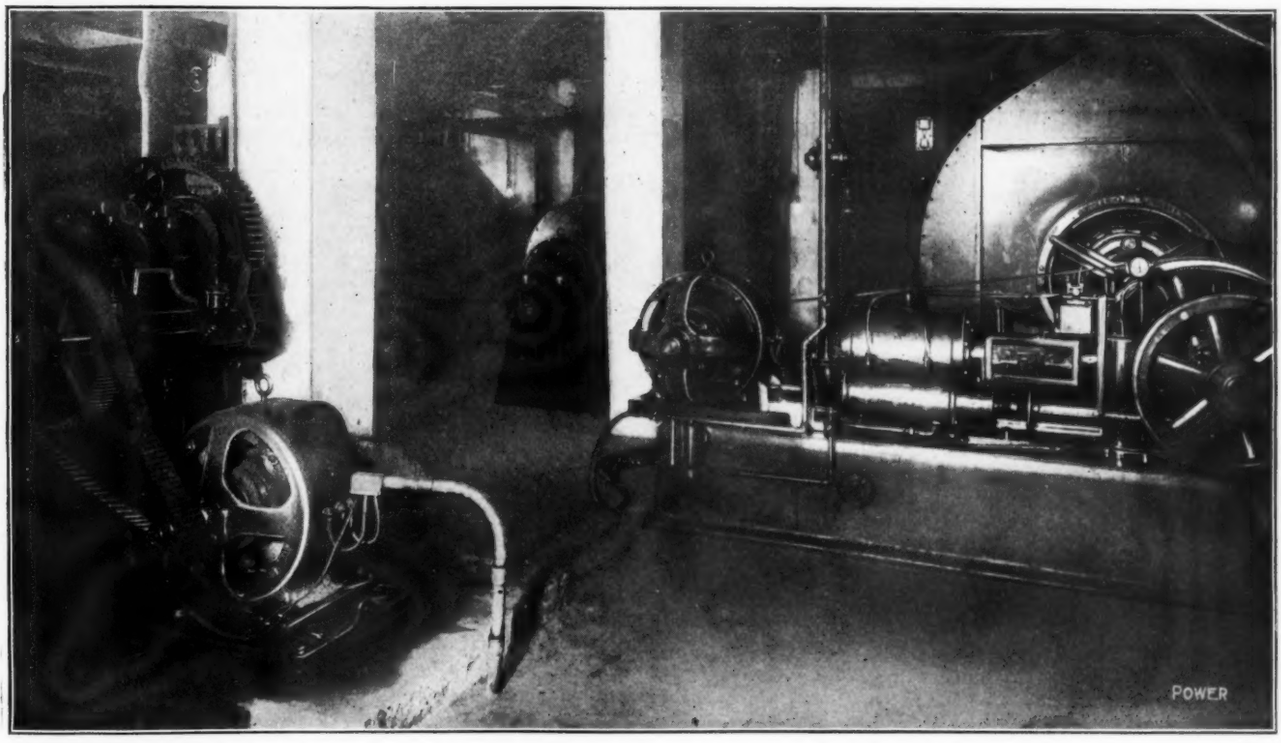


FIG. 8. VULCAN CLEANER AND ONE OF THE POWER PUMPS

each unit. Feeding three engines fully loaded and taking 40 lb. of steam per kilowatt-hour from one end of the header demand a steam velocity of 3200 ft. per min. in the loop and 1800 ft. in the engine-supply pipes. The loop is made up of extra-heavy steel pipe with vanstone joints and a valve at the center dividing the units two and three.

The exhaust pipes from each engine are 8 in. in diameter and under the conditions given for the supply with the discharge at atmospheric pressure and a quality of 87 per cent., necessitate a steam velocity of nearly 9000 ft. per min. This appears a trifle high and, on the contrary, the velocity of the supply is below the average. The exhaust pipes unite into a common 18-in. exhaust main discharging into a 5x10-ft. expansion tank or through a back-pressure valve to atmosphere. From the expansion tank one 12-in. pipe supplies the feed-water heater and three hot-water heaters for house service with exhaust steam. Another 12-in. pipe for direct heating rises to a pipe gallery above the twenty-third floor and feeds downward through 44 branches. From the same number of return lines the condensation from the heating surface is collected in a 6-in. header and returned to the heater by either of two 10 and 16 by 16-in vacuum pumps. The smaller taps to the expansion tank go to the indirect surface, and it will be noticed that there are two 10- and 14-in. blank flanges, one for the Ford Building and one for future use. A 6-in. pipe from the auxili-

ary boiler header supplies the expansion tank with live steam when necessary and a second pipe of the same diameter carries live steam to the feed and hot-water heaters, each of the latter having a capacity of 1400 gal. per hour. The low-pressure drips are collected in a drip tank and trapped to the sewer.

Miscellaneous Pumps and Fans

To indicate which of the auxiliaries are power driven and which steam, the following is a list of pumps and fans not previously mentioned. There are one 5½x8-in. triplex house pump driven by a 15-hp. motor, and one 2½-in. centrifugal for the same service. For the 30-ton absorption system there are two 6⅛ and 4 by 8-in. simplex pumps to circulate the drinking water, two 10 and 6½ by 12-in. pumps to circulate the brine to the restaurant and one aqua pump, 8 and 3½ by 12-in. There are also two motor-driven 4-in. centrifugal sump pumps and one 12 and 6½ by 12-in. elevator pump serving a hydraulic money lift, and a hydraulic elevator running between the first floor and the safety deposit vaults of the bank.

DIME SAVINGS BANK BUILDING

BOILER ROOM LOG

DATE_____

6 A. M. TO 6 P. M.		6 P. M. TO 6 A. M.		NO. OF HOURS BOILERS IN OPERATION			
COAL	ASH	COAL	ASH	NO. 1	2	3	4

LOADS OF ASHES DRAWN AWAY

FEED TEMPERATURE — 6 A. M. TO 6 P. M. / 6 P. M. TO 6 A. M.

REMARKS

FIREMAN ON WATCH: 7 TO 9 _____ 1 TO 11 _____ 11 TO 5 _____

Fig. 9. Boiler-Room Log

DIME SAVINGS BANK BUILDING

ENGINE ROOM LOG

DATE_____

		METER READINGS							
		NO. 1	2	3	4	NO. 1	2	3	4
VENTURI	P. M.					A. M.			
PREVIOUS	A. M.					P. M.			
WATTMETER	P. M.					A. M.			
PREVIOUS	A. M.					P. M.			
BEING STARTED	P. M.					A. M.			
BEING STOPPED	A. M.					P. M.			
WATER WEIGHER	P. M.					A. M.			
PREVIOUS	A. M.					P. M.			
STARTED HEATING SYST'M	P. M.					A. M.			
STOPPED HEATING SYSTEM	A. M.					P. M.			

REPORT BELOW ANY UNUSUAL CONDITIONS OR DEFECTS IN OPERATION, AND STATE TIME

ENGINEER ON WATCH _____

Fig. 10. Engine-Room Log

For blowing the motors and generators, for hot-water-heater control and in the barber shop, compressed air at 20 to 25 lb. pressure is required. This is supplied by two small compressors driven by 3-hp. motors. The vacuum cleaner requires a 15-hp. motor and the two air washers for the bank and restaurant have 1¼-in. pumps driven by 3-hp. motors. In the basement there are five fresh-air fans requiring a total of 40 hp. in motors and four exhaust fans taking 22 hp.

Records

With the meters and gages previously mentioned steam-flow meters soon to be installed on the outlet of each boiler, a CO_2 apparatus and a water weigher on the heating system, the facilities are good for the excellent system of keeping records shown herewith. Fig. 9 is the boiler-room log, Fig. 10 the engine-room log, and Fig. 11 the power-plant daily report sheet. From this sheet the monthly report is plotted on coördinate paper which is hung in a double roll on the wall, the records for the past month being rolled up as fresh paper for the current records is unrolled. The records for the entire year are eventually available on the roll.

DIME SAVINGS BANK BUILDING

POWER PLANT

DAILY REPORT SHEET

DATE_____

	6 A.M. TO 6 P.M.	6 P.M. TO 6 A.M.	TOTAL
Lbs. Coal Received			
Loads of Ashes Drawn Away			
Lbs. Coal Burned			
Lbs. Ash Removed			
Per cent. Ash			
Average Steam Pressure			
" Temp. Feed Water			
Factor of Evaporation			
Lbs. Water Evaporated			
Lbs. Water Evaporated from and at 212			
Lbs. Water Evaporated from and at 212 per lb. Coal as Fired			
Average B. H. P. Developed			
Lbs. Coal per B. H. P. H.			
K. W. Hours Delivered to Lighting Busses			
K. W. Hours Delivered to Power Busses			
Total K. W. Hours Delivered to Switchboard			
K. W. Hours Delivered to Elevator Circuit			
K. W. Hours Delivered to Auxiliary Machinery			
No. Hours Heating System in Operation			
Average Pressure on H. System			
Average Vacuum on H. System			
Lbs. Exhaust Steam			
Lbs. Live Steam			
Lbs. Condensate Returned from Dime Building			
Lbs. Condensate Returned from Ford Building			
Lbs. Condensate Returned			
Lbs. Condensate Returned from all Buildings			
Percentage of Total Evaporation Delivered to H. System			

REMARKS

Fig. 11. Power-Plant Daily Report Sheet

Albert Kern is manager of the Ford properties and V. L. Bowles is chief engineer of the plant. To the latter we are indebted for much of the information contained in this article.

Balancing of Machinery—In these days of high rotational speed, the whole question of the balancing of machinery has assumed redoubled importance, for, if there is any lack of proper balancing, the ensuing vibration will in magnitude be proportional to the square of the speed, while the number of times the vibrational force is applied per minute will vary directly as the speed. Thus, if we consider only fatigue stresses, the harmful effect of a given amount of lack of balance would increase as the third power of the speed of rotation.—"The Engineer."

Boiler Failed in Capacity—One of two 250-hp. boilers failed to develop its rated capacity. There being no flue-gas analyzing outfit handy, the plant manager arranged to determine the performance of all the boilers. A small hole was drilled in the rear wall of the boiler setting just below the line of lower tubes, and a small iron rod was inserted a short distance under the boiler. With the highest rate of combustion, the rod would melt at the end; with fairly good combustion, the rod became white hot; with excess air coming through the grate and a large percentage of the gas passing up the stack, the rod remained black or red. Because of these tests one boiler was discontinued, resulting in a saving of approximately one pound of coal per kilowatt-hour.

Effect of Speed upon Direct-Current Generators

By Gordon Fox

SYNOPSIS—Explanation and curves showing how a change in speed will affect the voltage regulation and the commutation due to increased armature reaction.

Not infrequently, direct-current generators are driven at speeds differing to some extent from those for which they are rated, and it is interesting to note the effect of

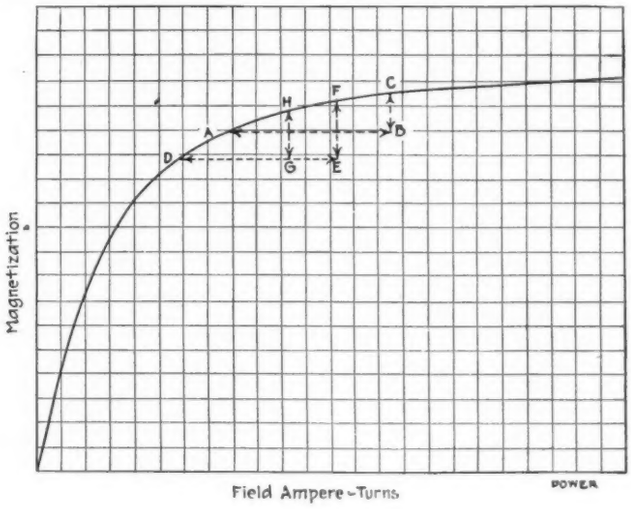


Fig. 1. Saturation Curve

such changes upon the operating characteristics. Two results may be more or less pronounced: First, the compounding or voltage regulation of the machine is changed, and, second, the commutation may be affected and a different neutral or best-running brush position occur.

The effect of speed upon compounding is shown in Fig. 1, which is a saturation curve for the magnetic

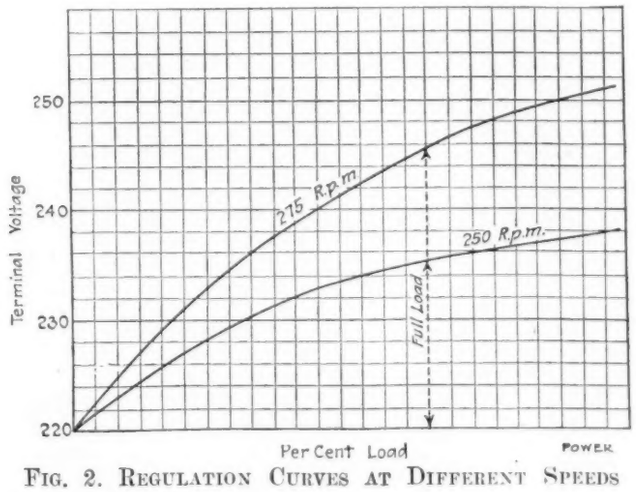


Fig. 2. Regulation Curves at Different Speeds

circuit of a direct-current generator, operating normally at 250 r.p.m. The 220-volt no-load point occurs at *A*, just above the knee of the curve, and the ampere-turns due to the series field are represented by *AB*. The increase in magnetic density caused by these additional ampere-turns in the field is shown by *BC*. This additional excitation causes an increase of 25 volts in terminal pressure between no load and full load at 250 r.p.m.

If this generator be speeded up to 275 r.p.m., it will operate over a different portion of the magnetization curve. Due to the increase in speed, the no-load voltage, 220 volts, will be delivered at a lower degree of saturation. This point will then occur at a lower portion of the curve, at *D*. The series field, still having the same ampere-turns with the same load, represented by *DE*, will have a magnetizing effect, *EF*. This increase in magnetization, due to the series field ampere-turns, is seen to be greater than before, the distance *EF* being greater than *BC*. Moreover, an equal increase in magnetic density will cause a greater increase in voltage at 275 than at 250 r.p.m.

The two regulation curves are shown in Fig. 2. The curve for the machine operating at 250 r.p.m. is similar to the portion of the magnetization curve from *A* to *C*. Internal-resistance drop and armature reaction tend to cause the voltage to decrease with the load, whereas the increase in terminal voltage due to over-compounding

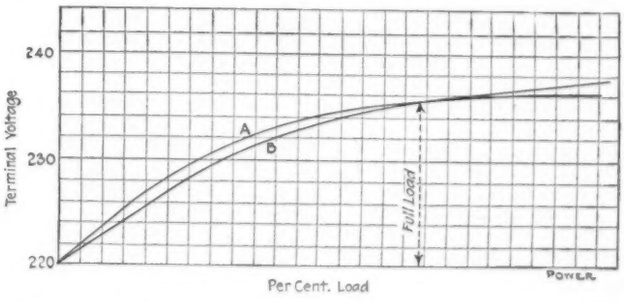


Fig. 3. Regulation of Two Equally Compounded Dynamos with Different Characteristics at Intermediate Points

causes the effect of the shunt field to increase, largely counteracting these tendencies. The curve for the machine operating at 275 r.p.m. is obtained by increasing each value of compounding effect, such as *GH* and *EF*, by the ratio 275/250. These values are not entirely correct, due to the factors noted above, but are close approximations for comparison.

It will be seen that a change in speed of a direct-current generator will cause a considerable change in its compounding characteristics. Machines operating above speed will usually require a german-silver shunt around the series field to maintain the over-compounding at the desired value.

The portion of the magnetization curve over which a generator operates may have an important effect when two machines are paralleled. Fig. 3 shows the voltage regulation curves of two generators equally over-compounded in that the rise in voltage from no load to full load is the same for both. At intermediate loads, such as half load, there is considerable difference in voltage, so that if the machines be connected in parallel, ma-

chine *A* will tend to take the greater share of the load at this point. This makes it apparent that a correct division of load cannot be maintained over the entire operating range if the two or more generators in parallel have dissimilar regulation curves. As previously stated, the shape of the regulation curve depends largely upon that portion of the magnetization curve over which a machine operates. It was shown that a change in speed will change the operating point on the magnetization curve, hence it is evident that it is generally possible by adjusting prime-mover speeds slightly to modify the compounding curves in such a manner as to improve the load division by causing the machines to have similar voltage regulation characteristics.

The second effect of speed change is in respect to commutation. If a machine be driven above normal speed it will deliver rated voltage at a lower degree of magnetization than normal. If the iron be thus less saturated, the effects of armature reaction will be more pronounced, the neutral more widely shifted with load changes and sparking more likely to take place. The full-load neutral will probably occur at a different point than that for normal operation, so that a relocation of the brushes will be desirable.

Advantage of this feature may be taken in an opposite manner. If a generator operating at normal speed shows a tendency to sparking and it is found that the neutral point shifts widely with the load, indicating a strong armature reaction effect, then it may be possible to remedy, or at least to alleviate, the difficulty by slowing down the drive a little. This will cause the generator to operate at a higher degree of saturation in order to deliver its rated voltage. Operating at the higher magnetic density, the neutral will be more stable and commutation should be improved. This has the effect of increasing the relative field ampere-turns with respect to armature ampere-turns, a change productive of better commutation constants.

Centrifugal-Fan Characteristics

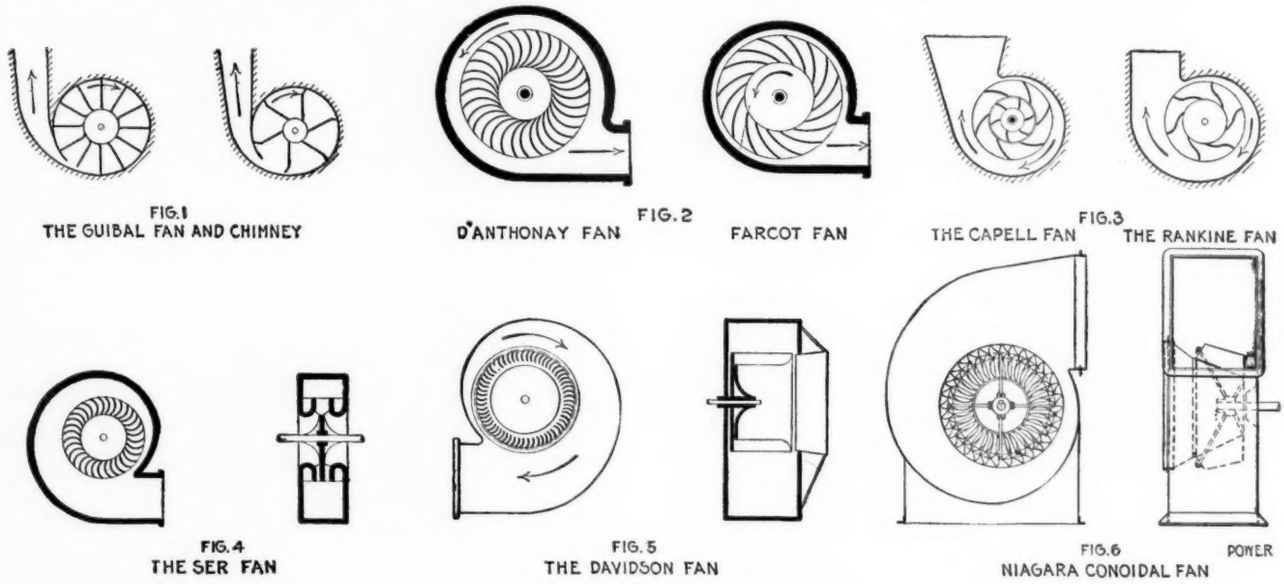
By Frank L. Busey*

SYNOPSIS—The performance of a fan depends largely upon its intelligent selection to meet the operating conditions. When to choose a multi-vane and a straight-blade fan. Static and total efficiencies are also defined.

The centrifugal fan is meeting with increasing application in general engineering practice, yet little attention has been paid by the majority of engineers to the advancement in design and construction of fans, or to the performance and selection of the various types. The electrical engineer now uses fans for generator cooling; the power-plant engineer for forced and induced draft as well as for the removal of ashes and the cooling of hot boiler rooms; and the operating engineer in industrial or public-building installations uses fans for heating, ventilating and cooling. The fan also has many special applications in various industries, such as furnishing blast to forges and furnaces; the removal of industrial waste by means of exhaust systems and the supplying of air for various drying and manufacturing processes.

The term "centrifugal fan" designates that form of construction commonly known as the steel plate or multi-blade type as distinguished from the positive blower type, such as the Root or Connersville. It is used to work against comparatively low pressures, ordinarily only a few ounces, or at most about 16 oz., and is made up of a rotating arbor or plate to which are attached a series of blades. When this drum is rotated, the columns of air between the blades are given a centrifugal motion, delivering the air from the center to the wheel circumference.

In different forms, the centrifugal fan has been built for over 200 years, and even as far back as 1847 a Mr. Buckle presented data before the Institute of Mechanical



Different Types of Fans

*Deceased.

Engineers for the design of fans which does not differ greatly from present practice. In 1872 the first complete treatise on the theory of the centrifugal fan was published by Daniel Murgue, engineer to the Colliery Company of Besseges, and this theory is still accepted by authorities on fan performance. These earlier fans were used largely for mine ventilation, and later for the ventilation of tunnels. At first they were simply for exhausting and were not fitted with a housing. In this way only the centrifugal velocity was employed, and no benefit was derived from the rotational velocity.

Some of the earliest fans are shown by Figs. 1 to 3, from which it will be noticed that some were fitted with a cone-shaped discharge, intended to reduce the velocity

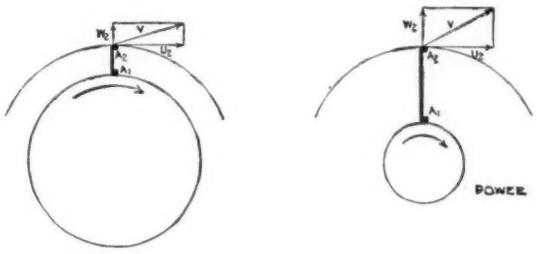


FIG. 7. EFFECT OF CENTRIFUGAL ACTION IN FAN WHEELS

of the air. This same principle is still used in fans for mine ventilation. The earliest fans were built both with straight and with curved blades, but these blades were always long radially, and in some cases the housing was circular instead of spiral in shape; therefore, no benefit was obtained from the centrifugal action of the air within the fan wheel, and only the velocity of discharge was utilized.

One of the first multivane types using short curved blades was designed by Professor Ser, of Paris, about 1884, a sketch of which is shown in Fig. 4. Numerous other designs of curved-blade multivane fans were patented within the next 15 years, but the most widely known is the Davidson patent, more commonly called the Sirocco fan, shown in Fig. 5, which represents the fan as first patented, in 1900. Various American fan builders have brought out multivane fans within the last few years, generally differing in some essential feature from the Sirocco fan.

One of these is the Niagara Conoidal fan, Fig. 6, which embodies two special features: First, the diverging cone effect is brought back into the fan housing, giving an actual lower outlet velocity and a consequent higher static pressure; secondly, the wheel is different in its design from anything previously built. The blades are of greater depth radially at the back than at the front, and are generated on a cone by a generatrix not parallel to the axis. By making the tangential velocity less at the back of the wheel than at the front, the difference in centrifugal velocity is so balanced as to give an even pressure across the entire tip edge of the blade.

RELATIVE PERFORMANCE OF STRAIGHT- AND CURVED-BLADE TYPES

In any centrifugal fan there are two separate and independent sources of pressure: First, the centrifugal force due to the rotation of the air within the wheel; second, the kinetic energy contained in the air by virtue of its velocity upon leaving the periphery of the fan rotor. The action of the centrifugal force upon the particles of air within the fan wheel may be illustrated by the two diagrams in Fig. 7. Due to the centrifugal force, a particle of air at A, at the heel of the blade, will be thrown to the tip and given a velocity W_2. The resulting velocity V is the combined effect of W_2 and the rotational velocity U_2. From a comparison of these two figures it is evident that a fan with longer blades, if they are both straight, will give a greater pressure than may be obtained from a short-bladed fan at the same speed.

By curving these short blades either forward or backward, as in Fig. 8, any desired variation in velocity may be obtained for the air leaving the tip of the blade. Thus when the blade is bent forward, a pressure greater than that corresponding to the peripheral velocity will be obtained. This results in the same pressure at a lower speed than would be necessary with a straight blade and the same wheel diameter. In case it is desired to directly connect a fan to a high-speed unit without developing the corresponding high velocity, the blade may be bent backward.

Centrifugal fans may be divided roughly into two classes, those with straight radial blades and those with blades curved with reference to their direction of rotation. The amount of total pressure developed by a straight-blade fan may be mathematically determined, but in the case of a curved-blade fan this can be known only by actual test.

An essential feature is the housing in which the wheel or rotor is inclosed. The kinetic energy of the air leaving the periphery of the wheel to a great extent must be converted into potential energy in the form of static pressure before being serviceable. This conversion from kinetic energy or velocity into static pressure is ordinarily accomplished in the scroll formation of the fan housing. A still further conversion is often secured, where the velocity leaving the outlet is high, by means of a diverging nozzle at the outlet. The shorter the blade, the greater must be the dependence on the scroll-shaped housing to obtain the desired static pressure, and for this reason a properly designed housing is of more importance with a multivane fan than with the older straight-blade type.

The standard steel-plate fan may be considered as a

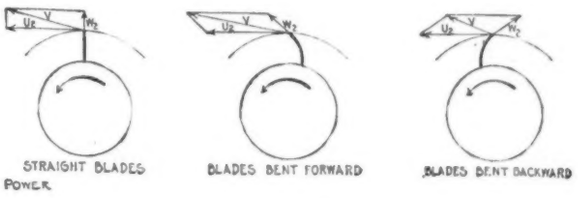


FIG. 8. RELATIVE EFFECT OF DIFFERENT-SHAPED BLADES

specimen of the straight-blade type, although if the tip of the blade is bent in either direction, the characteristics will be slightly changed. The ordinary steel-plate fan does not give as high an efficiency as the multivane type, because it is designed for large capacity rather than for high efficiency. But if these straight-blade fans are made long and narrow, with a smaller inlet than is used on the standard fan, they may be made to give higher efficiencies than can be obtained from any of the multivane type of fans.

The size of inlet depends on the cubic feet of air handled per revolution of the fan, and there is a certain diameter of inlet that will give maximum economy. The smaller the inlet diameter as compared to that of the wheel, the greater will be the efficiency obtained, but at a sacrifice in capacity.

Relation between Static, Velocity and Total Pressures and between Static and Total Efficiency

Frequent reference has been made to static and velocity pressures, and also to the conversion from velocity pressure to static pressure at the fan outlet. In practically all installations using centrifugal fans there exists a certain static resistance of the system to be overcome. One common source of such resistance is the loss by friction due to transmitting the air through a system of ducts, which varies with the roughness of the surface, the resistance of elbows or other obstructions, and as the square of the air velocity. A further source is in the fuel bed of furnaces or the grates of a boiler; the resistance offered by the boiler itself or by an economizer in the case of an induced-draft fan; the loss in head at the hoods and through the collector in an exhaust system; and the resistance of the heating coils or air washer in a heating or ventilating installation.

It is necessary for the fan to develop a definite static

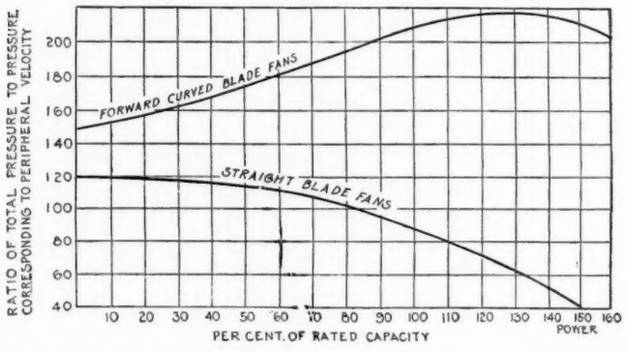


Fig. 9. Pressure Characteristics at Constant Speeds

pressure sufficient to overcome the various static resistances of the system. In addition to the static pressure, the air has imparted to it a certain velocity pressure due to its velocity on leaving the fan outlet. This velocity is dependent on the amount of air handled and on the area of the fan outlet.

The total pressure is the velocity pressure at the fan outlet plus the static pressure of the system, and is the pressure upon which the performance and efficiency are usually based. In the case of an exhaust or "draw-through" system, the static head should be taken as the difference in static pressure at the inlet and outlet of the fan, one being positive and the other negative.

The relation between static and total pressure and between static and total efficiency is not generally understood. Many consider only the total efficiency, even when the resistances are estimated in static pressures. The static pressure is the potential energy developed by the fan, and is the energy available for performing useful work in overcoming the frictional resistance of the system. The velocity pressure is the kinetic energy used in moving the air and is a measure of the air quantity handled, but until it is converted to static pressure it is not available for overcoming resistance.

Thus it is seen that the greater the static pressure developed at the fan outlet in proportion to the velocity pressure, the more effective will be the performance of the fan in overcoming frictional resistance, and therefore the greater the "static efficiency." The efficiency is the ratio of the power output to the power input, or the ratio of work done in delivering a certain amount of air against some known pressure to the work done by the engine or motor used in driving the fan. There may be two different efficiencies, static or total, depending on whether static or total pressures are considered. Since the total pressure is greater than the static, the total efficiency is greater than the static efficiency, and for this reason the efficiency generally referred to in fan performance is based on the total pressure.

A fan having a high total but a low static efficiency may be less desirable than another having a high static efficiency but relatively lower total efficiency. The static efficiency may be readily calculated when the ratio of static to total pressure at the rated capacity of a fan is known. Thus, if the static pressure is 80 per cent. of the rated total pressure, the static efficiency will be 80 per cent. of the total efficiency.

The efficiency, in terms of either the static or total pressure, may be calculated by means of the following formulas:

$$\textit{static efficiency} = \frac{0.0001565 \times Q \times \textit{static press. (inches)}}{\textit{horsepower input}}$$

$$\textit{total efficiency} = \frac{0.0001565 \times Q \times \textit{total press. (inches)}}{\textit{horsepower input}}$$

where Q equals the quantity of air in cubic feet per minute.

Relative Pressure Characteristics of Steel-Plate and Multivane Fans

As may be seen from Fig. 9, the pressure characteristics of a fan having forwardly curved blades are quite different from one having straight blades. This is not generally understood and is often overlooked in the selection of a fan for any specific duty. It will be noted from the curves that when a fan with forwardly curved blades is operated at constant speed and at less than the rated capacity corresponding to that speed, the total pressure developed will be less than the rated pressure at rated capacity. Given this same condition with a straight-blade fan, operating at constant speed, the pressure tends to increase as the load on the fan is reduced.

These relationships are frequently of great importance in the selection of a fan, and numerous disappointments in performance may be traced to the fact that the fan was not adapted to the conditions under which it was to operate. Thus if a fan be used to supply forced draft to a boiler, when an additional load comes on and an extra supply of coal is added to the fire, an increase in pressure should be available to overcome the extra resistance of this fresh fuel and keep up the rate of combustion. It will be noted from Fig. 9 that unless the fan speed is increased, a multivane fan under these conditions will give a decreasing pressure. Owing to the thickening of the fuel bed, the delivery of the air is throttled, and as the capacity of this type of fan is decreased below the rated point, the total pressure falls off. Just the opposite will hold true of a straight-blade fan. On the other hand, if a fan is to be operated at considerable overload without an increase in speed, the pressure of

the straight-blade fan will fall off, but the total pressure of a forwardly curved multivane type of fan will increase.

A better conception of the relative performance of the two types may be had from a comparison of the diagrams in Figs. 10 and 11. The curves in Fig. 10 show the relative performance of a straight-blade steel-plate blower of standard make, and gives the performance at other than the rated capacity. The horsepower characteristics for this type give a straight line. According to the curve, the rated total efficiency for this fan is 50 per cent.

The curves in Fig. 11 show the relative performance of a well known fan of the forwardly curved blade multivane type. If this fan is operated at 50 per cent. of the rated capacity but at rated speed, the static pressure will be about 83 per cent. only of the rated and there will be a drop in static efficiency of approximately 10 per cent. One advantage of this type may be noted from Fig. 11, where it will be seen that the static pressure curve is comparatively flat at the point of rating, and that a considerable range of capacity may be obtained without serious loss in efficiency. Also, as seen from the horsepower

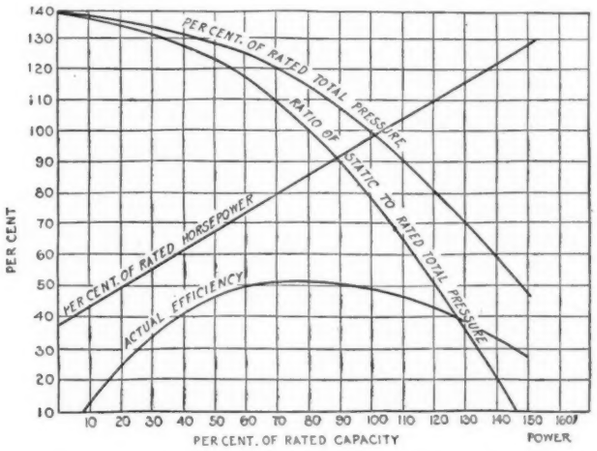

PER CENT
PER CENT. OF RATED TOTAL PRESSURE
RATIO OF STATIC TO RATED TOTAL PRESSURE
PER CENT. OF RATED HORSEPOWER
ACTUAL EFFICIENCY
PER CENT. OF RATED CAPACITY
POWER

FIG. 10. PERFORMANCE CURVES OF STRAIGHT-BLADE TYPE

curve beyond the point of rating, the power consumption goes up very rapidly, with an increasing total pressure. This explains why this type, when motor-driven, is so likely to overload the motor and why care should be taken to specify a motor sufficiently large if there is any possibility of an excessive overload.

CONCLUSIONS

From the foregoing it will be seen that different types of fans have widely different characteristics, and should be intelligently chosen if the best results are to be expected. While the impression seems quite general among engineers that the multivane fan is inherently more efficient than the steel-plate type, this is true only of the commercial steel-plate fans as ordinarily placed on the market. These fans are designed for large capacity rather than for high efficiency, but if properly designed, a straight-blade steel-plate fan may be made to give even higher efficiencies than multivane fans. This calls for a tall, narrow fan.

The multivane fan is of special advantage where space (more particularly head room) is of importance. Its higher speeds are also an advantage, since they allow direct connection to higher-speed motors, or give better pulley ratios where the fan is belt driven. Where a constant or increasing pressure is required when operating at less than the rated capacity, the straight-blade fan should

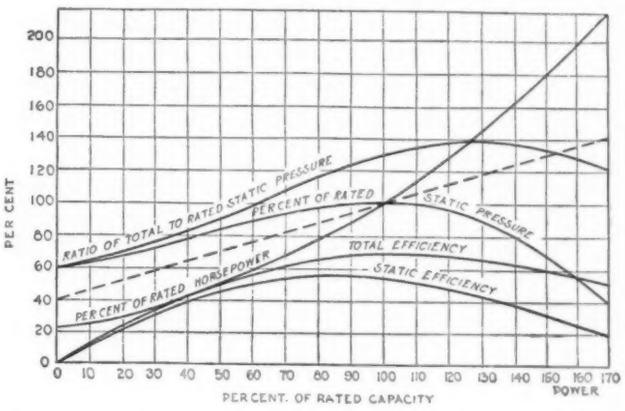


FIG. 11. PERFORMANCE CURVES OF CURVED-BLADE TYPE

be used, but the multivane type is the better one to use where a constant or increasing pressure is required above capacity.

Formula for Self-Supporting Steel Stacks

BY W. S. DURAND

Steel chimneys are coming more and more into favor, especially where ground space is limited or the stack is erected over the boiler and the area occupied by the boiler has to be incorporated with that required for the chimney. Steel stacks also have the advantage of being easily and quickly constructed, have less weight for a given diameter and height and have less surface exposed to the wind; they also cost much less than other types of chimneys. The main disadvantage seems to be that the upkeep cost is greater since a steel stack must be kept well painted to prevent corrosion.

In most cases, steel chimneys are self-supporting and are generally made with a bell-shaped base 1½ to 2 times the diameter of the stack. This is riveted to a heavy cast-iron plate bolted to the foundation. The steel is thickest at the bottom and decreases toward the top of the stack. The proper thickness for any given section may be determined by treating the shaft as a uniformly loaded cantilever, the wind being ordinarily the only force tending to overturn the stack since it is rigidly bolted to the foundation

Without going into the necessary steps leading to the solution of this problem, the equation of moments may be reduced to the final form:

$$Ph = S\frac{\pi}{32}\left(\frac{D_1^4 - D_2^4}{D_1}\right)$$

Where

P = Total wind pressure in pounds;
h = Distance from center of wind pressure down to a given point for which the thickness is to be determined;
S = Safe stress in pounds per square inch of material;
D_1 = External diameter of the shell in inches;
D_2 = Internal diameter of the shell in inches.

This is the usual formula appearing in most books on the subject, but it is rather complicated and requires considerable time for its solution. By using different notation and a slightly modified form for the moment of inertia, the formula for thickness may be expressed as,

$$t = \frac{Ph^2}{\pi Sr}$$

Where

t = Thickness of shell in inches;
P = Wind pressure in pounds per square foot;
h = Distance from top to the section under consideration, in feet;
S = Safe stress in pounds per square inch;
r = Half diameter in inches.

Single-riveted joints are ordinarly used on stacks, but where great stiffness is desired all girth seams are double riveted. Allowing 6000 lb. per sq.in. as a safe stress for single-riveted joints, 8000 lb. for double-riveted joints and a maximum wind pressure of 25 lb. per sq.in., this formula, for all practical purposes, may be considered as reducing to the following simple forms:

For single-riveted girth joints,

$$t = \frac{h^2}{750\,r}$$

For double-riveted girth joints,

$$t = \frac{h^2}{1000\,r}$$

The least thickness that should be used is $\frac{3}{16}$ in., and where the stack is over 7 ft. in diameter, or 150 ft. high, the thickness should not be less than $\frac{1}{4}$ in.

Oils and Lubrication--II

By L. D. Allen

As the writer has never found laboratory tests of much practical value in the selection of oils, greases and babbitt metals, he has of necessity confined his remarks to that which he has observed and has been told in exchanging experiences with engineers and machinists on the firing line who had to do with the use of these commodities in a practical way. The distrust of testing-machine results is due to the fact that testing-machine journals are as perfect as care and the machinist's skill can make them, whereas in actual mill, factory and shop use they are not only less perfect, but are subject to all sorts of varying conditions, and more particularly the conditions indigent to each plant. Even the oiling devices are entirely different. The bearings of the testing machine may be made of babbitt, while the oil that showed up so beautifully on these babbitted bearings may be used in bronze or brass bearings and the slight proportion of free acid in the oil or grease, as the case may be, which had no effect on the babbitt, will at once start corrosion on the surface of the bronze or brass.

The laboratory may contribute much toward showing to what extent an oil or grease has been doped with deteriorating products, but when the extent of its adulteration escapes detection in many of the ordinary tests then the quality is affected hardly enough to make any noticeable difference in its lubricating value for general bearing requirements. This little difference, however, existing in each bearing throughout a large mill, factory or plant, foots up a considerable item, and, as an engineer suggested, the answer to the question of oil economy is whether more or less power is required. The oil, grease or babbitt may seem to be doing all right, but what is it costing at the power end?

Oil, like water, when heated by friction, evaporates, passes off like steam and is lost into space with the heat it has absorbed. This transformation is said to take place at the point where the shaft rests heaviest in the bearing. The greasy appearance of the face when one has spent a day in an engine room shows how thoroughly the air is charged with oil vapor.

With the new oils having greater viscosities and lower gravities, the specification and simple test methods that have prevailed for years must be confined to oils produced from the same crudes.

Pennsylvania and Southwestern Crudes

The oils from the Western and Southwestern crudes are now being sold on factory results; the Pennsylvania or paraffin-base oils are still being handled on the old specification basis. For those who are using the Pennsylvania oils the following will be of interest.

Up to recent times, the Pennsylvania crudes have had the reputation of giving oils that make the best light-spindle lubricant, and oils that stand the highest temperatures for automobile service, while the California, Texas and some Western crudes produce the heavier hydrocarbons that possess the body best for general machinery lubrication where there are great stress and heavy loads.

From recent scientific tests made on internal-combustion engines it has been proved that those oils which have been refined from low-gravity crudes—the Texas and California crudes—show in the combustion chamber a carbon formation of a softer nature than oils refined from a paraffin-base crude, an obviously desirable feature.

The red oils represent the stocks used in general machinery lubrication; the light brown, lemon and pale lemon are the oils used in high-speed engine, motor and automobile service, grading to the extra pale and water-white oils used in spindle-bearing, sewing-machine and clock lubrication and places where stainless oils are required. The Southwestern crudes produce the higher viscosity oils without the aid of admixtures. These may run in color from red oil to lemon; the same is true of the paraffin-base oils. It is a known fact that for steam-cylinder lubrication it is necessary to use a cylinder stock refined from a paraffin-base crude. This may be Pennsylvania, Ohio, Indiana, Illinois or Oklahoma crude, all of which give equal results if the stocks are carefully selected to meet the operating conditions. The dark steam-refined stock is most generally used as it has a high flash test and shows greater viscosity. Being

a petroleum product, however, it has no affinity for moisture. It will not stick to wet cylinder and valve surfaces, and must, before it is a good steam lubricant, be compounded with a certain amount of fatty oil, usually tallow, so that it will emulsify and cling to the surfaces.

Engine-Room Tests

Following are some of the common engine-room tests for ascertaining quality and uniformity that have been quite generally used with Pennsylvania lubricants:

For gummy conditions, spread the oil on a glass plate and expose it to dry heat. The sticky nature of the residuum, or what is left, indicates the extent of its gummy qualities.

To get an idea of the real lubricating body or viscosity of an oil, get two or three glass tubes of the same dimensions, fill them to the same extent and allow the oils to drop out of the small ends of the tubes. See which of the two or three oils drop the quickest. The most viscous oil will move or drop the slowest. By varying these tests at a cooler or warmer temperature, the evenness of the viscosity can be determined. The most practical temperature, of course, is that which corresponds with the general running temperature of the bearings in which the oil is to be used.

Another test for ascertaining the clinging qualities, as well as the viscosity of an oil, is to pour a drop of each of several oils at a slight distance from each other on a clean inclined glass plate, having the plate at about the temperature of the bearings, and notice the time it takes for each drop to reach the bottom. By changing the temperatures, the uniform consistency can be determined.

Place two oils side by side on clean blotting paper resting on a steam heater. The oil which evaporates the quickest and spreads the widest is the thinnest oil. It shows by its lightness that it is compounded with material of light specific gravity. If exposed for some time and all of the oil disappears, it shows that it is all petroleum. Pure petroleum penetrates the blotting paper faster than when compounded with fatty oils. When pure petroleum dries off, the translucency disappears. When a compound with fats drys, the blotter is permanently translucent. When an inner ring with a well defined form is noticeable, it indicates compounding with a light paraffin stock.

The specific gravity of an oil indicates its density or weight. This is easily determined by a hydrometer, which can be obtained at a trifling cost and requires no skill in its use. It should be thoroughly cleaned for each lot of oil tested. A combination hydrometer and thermometer is best.

Of all the tests, either laboratory or those just stated, the most essential test is to place a thermometer in contact with the bearing and determine the frictional temperature, that is, the temperature of the bearing minus the room temperature. The oil showing the lowest frictional temperature under like mechanical conditions is the best lubricant for that bearing.

For steam-cylinder lubrication the best practice is to check the cylinder-oil consumption for an hour's run. If possible, remove the cylinder head and determine the oil film by aid of tissue paper, noticing the number of sheets of paper penetrated by the oil film; this will give an idea of the extent of the lubrication being furnished. A good method is to use an ordinary stethoscope, which will enable the operator to distinguish the least groan or distress either in the cylinder or in the valves.

A lubricating oil should be free from sulphur compounds. A test to determine whether sulphur remains in the oil is to heat it to about 300 deg. F., maintaining the temperature for 15 min., then cool and compare the color with the original oil. If it is darker, it indicates that the oil has been badly refined. A great variety of bearing linings will not stand the corroding effects of sulphuric acid.

The flash point of an oil is that point in temperature at which enough vapor arises to ignite in the form of a flash over the surface when brought in contact with a flame. It is an important factor in determining the suitableness of oils that must stand high temperatures. In making the test, the flame should be brought only near enough to the oil to reach the vapor, say within ¼ in.

In textile mills and wherever the fire hazard has to be guarded against, special attention should be given to the flash point of the lubricant. Also, the flash point is an important item in the use of cylinder oils, as oils of high flash point evaporate less quickly.

The fire test shows the point at which the oil itself will ignite or burn, and is usually from 50 to 75 deg. higher than the flash temperature.

The cold test is the point at which the oil congeals. The most doubtful test is that concerning the viscosity of an oil because the viscosity may be due to the presence of wax or some form of adulterant. To the average layman, it is impossible to determine adulterations or, in other words, false viscosities except by noticing the differences in temperature on the same bearing. An adulterated oil will show greater frictional loss and naturally higher temperature.

Color is not a determining factor except in the case of selecting an oil for use on spindles where something is wanted that will not stain. The general machine oils are a ruby red and the motor and auto oils an amber or lemon color, varying in lightness and darkness according to their body or degree of refinement.

The gravities of oils are governed by the crudes from which they are made. The high-gravity oils are produced from the Pennsylvania crudes, while the Western or asphalt crudes show a lower gravity; the lower gravity indicates a greater carbon content.

Oils for Different Uses

A good all-round red oil for general lubrication made of Western or asphalt crudes will show 23 to 24 gravity, about 395 flash and 250 to 295 viscosity, while an oil used for the same purposes made from Pennsylvania crudes will show about 30½ gravity, with the other points about the same except the viscosity, which will be lower. Competitive tables showing comparative viscosities of oils are not to be relied upon unless the temperatures at which the tests were made are the same.

Heretofore it has been custom on the part of oil salesmen to recommend for high-speed motors, dynamos, planers, etc., oils ranging in gravity from 30 to 32, flash 380 to 480, viscosity 180 to 225; an oil for gas-engine use ranging in gravity from 23 to 25, flash 390 to 420, viscosity 200 to 350; general machine work, light line shafts, etc., a 23 to 26 gravity oil, 360 to 395 flash and

150 to 295 viscosity; steam-cylinder stock for pressures up to 150 lb., a 600 stock with about 6 per cent. tallow, for over 150-lb. pressure a 650 stock with 8 per cent. tallow, and for superheated steam but a very small portion of tallow with 625 stock. With too much tallow in superheated steam, steric acid is formed, which adheres to the cylinder walls and cuts the rings. The flash of a cylinder stock should not be below 500; the fire test is around 650; the Pennsylvania auto oils range in gravity from 30½ to 31, flash about 415, viscosity 215 to 225, amber color. For crusher bearings a cylinder stock compounded with a cheap black oil is generally used; for light spindle work, a water-white oil of about 34 gravity, 340 flash, low viscosity of 85 to 100. However, as previously suggested, with the new charactertistics being developed in oils, new standards are doubtless being created and lubricants will be selected more on the basis of what they will do than on what they show as to gravity, flash, viscosity, etc.

Oils for turbine lubrication must not emulsify with water, and those used in transformers and conditions where electricity is a consideration, must be free from conducting substances. For these purposes filtered oils are required. In the steam turbine the oil is exposed to such high speed and, consequently, high intermolecular friction, that it will change in character after a certain period of use. Further, the nature of the lubricant must be such that it will quickly settle and separate from the water of condensation with which it becomes mixed so that it can be used again. The reason why developments along this line are so slow is because mechanical engineers are handicapped in their lack of knowledge on oil matters, and because, heretofore, lubrication has not involved to any appreciable extent the chemical character of the lubricant.

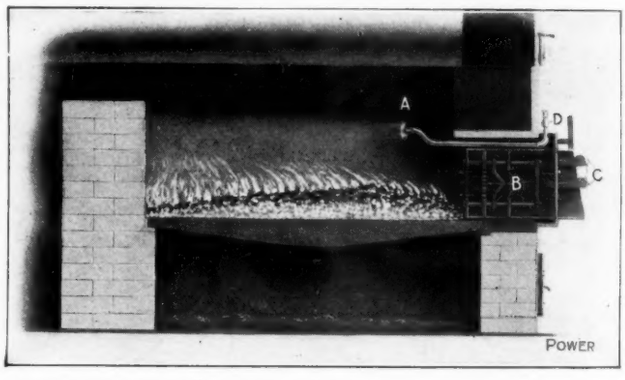
In a combustion engine the oil is not only constantly exposed to high speed and friction, but also to high temperatures. Both of these conditions tend to form substances rich in carbon by either decomposition or polymerization. The troubles are that oils will deposit carbon in the cylinders and start corrosion on the metal surfaces, and the spaces between the spark plugs become clogged. When applied to a vertical gas engine the oil will be divided into two parts, one working into the upper part of the cylinder above the piston, and the balance flowing back into the oil chamber below the piston. The part which comes into the cylinder is subject to high temperature, and the part which runs back, to high friction and some heat. In both cases the oil is greatly taxed chemically. With an ideal oil, that part which comes into the upper part of the cylinder should burn up completely without residuum, and the part which runs back should not form any asphalt or gum.

It is claimed that much trouble arises in getting results from good oils on account of a lack of scientific compounding of one oil with another. Oftentimes, it is a case of internal friction and disturbance in the oil itself due to the combining or attempting to combine two nonaffinity oils. The dealer in attempting to produce a certain gravity and viscosity by combining one grade of light oil with a grade of heavy oil without the necessary instruments and facilities to determine the physical and chemical constituents of each oil, and without knowing whether the two oils are produced from the same crudes, does not know what kind of an oil he is getting. True, this is bringing the discussion down to a fine point, perhaps too fine to be of value in general machine shop and factory work. In a large plant and in the operation of high-powered machinery the right oil is a big item. The above shows how futile it is for a buyer or large consumer to depend on specification purchases for results. It is a question for the oil producer and his engineer working in conjunction with the engineer or millwright of the plant to be supplied. Aside from the considerations of temperature of the bearing and the viscosity and wearing qualities of the oil, serious attention must be given to the design or construction of the bearing in relation to the duty imposed, the nature of the bearing lining, and the effectiveness of the lubricating devices and ways to keep an oil film between the surfaces of the bearing and the revolving shaft.

Aube Smoke Preventer

This device, adaptable to all furnaces burning bituminous coal, either alone or with sawdust or shavings, consists primarily of a patented furnace door which is pierced with apertures fitted with shutters and governed by an automatic regulator, so that air is admitted in the required amount. A furnace equipped with this smoke consumer is shown in the illustration.

To the inner side of the door is attached a boxlike structure projecting over the fire. In this device there is



SHOWING BAFFLE BOX AND STEAM-JET NOZZLE OF AUBE SMOKE PREVENTER

a succession of baffle-plates that can be independently adjusted so that the air in circulating around the baffles reaches a temperature sufficient to cause a high rate of combustion of the fuel in the furnace. These plates can be adjusted to conform to the peculiarities of each individual furnace.

In connection with the device, a steam jet is used which throws a fan-shaped stream of superheated steam over the fire while the furnace is being stoked. The jet serves as a blanket and keeps the cold air from striking the boiler plates and cooling them; it also holds the smoke in subjection until the fire-door is closed and the preventer gets into action. The steam jets are controlled by an automatic regulator set to shut off the steam when it is not needed.

This smoke preventer, manufactured by the Aube Smoke Consumer Co., Springfield, Mass., calls for no special skill or training in its use; it is automatic, and merely opening the furnace door puts the device in operation; every part is easily accessible.

Rules for Firing without Smoke*

By Osborn Monnett†

SYNOPSIS—How to build, clean and bank fires. In carrying a thick fire the coal is dumped in piles instead of being spread over the grate. The volatile matter is distilled in amounts which the furnace can care for and less smoke is produced.

Building Fires

Cover the grate with coal to a depth of about 4 in., and build a wood fire on top, or throw live coals from another boiler into the furnace at the bridge-wall. The green coal underneath will then ignite and burn. As the coal in the front gradually ignites, the volatile matter must pass over the fire already on the grates. A live, good steaming fire can be built up in this way without producing dense smoke. Keep the doors cracked and the panels wide open, giving the fire sufficient air and allowing the fresh coal to be ignited from the top. This will keep the smoke down to a minimum. When the coal has fully ignited and has been well coked, fire six or eight scoops of coal on one side, beginning at the bridge-wall and filling up the low spots all the way to the front. Do not spread the coal but allow it to lie in lumps just as it leaves the shovel. Before the fire gets too low on the other side, and after the greater part of the volatile matter has been burned off from the last charge, fire an equal amount of coal on the other side as before, always keeping the panels wide open after firing.

When enough steam has been generated, use the jets, turning them on before firing and leaving them on until the bulk of the volatile matter has been distilled off. Always use the alternate method. For smokeless operation, hand-fired boilers burning coal exclusively should not exceed a capacity of 150 hp.

Cleaning Fires

Build up the fire on one side and let the other side burn down. Just before cleaning, "wing" over the live coal from the burned-out side and pull out the clinker and ash, cleaning the grates thoroughly. Cover the clean grates with green coal and push over live coal from the other side. When the cleaned side has become thoroughly ignited and the volatile matter has passed off, throw in coal to fill the spots not covered and pull the clinker and ash out of the other side. Cover the grates with green coal as before, winging over live coals from the opposite side. Keep the panels wide open and allow the fresh coal to ignite thoroughly. Never allow the fire to burn low before cleaning if carrying a heavy load, as there is a possibility of losing the steam pressure. After cleaning, follow up closely with the alternate method of firing until the fuel bed is thick enough to hold the pressure.

Carry as thick a fire as the draft will permit and do not spread the coal over the grates.

Banking Fires

Throw 15 or 20 scoops of coal on each side. Open the panel doors slightly, close the ashpit doors and partially close the damper. To break up the bank, level the fire, with the panel doors open, and start firing by the usual method, making sure the damper is wide open.

Keep the fire thick by the alternate method, using the panel doors and steam jets, and regulate the steam pressure with the ashpit doors. This insures a temperature in the furnace high enough to maintain the brickwork at the igniting point of the coal and promotes combustion of the volatile matter. At the same time, it keeps down the distillation of the volatile matter to a low rate, and by having the damper open and the panels cracked, the circulation of the gases is not retarded. Do not try to regulate the steam pressure by the damper or smoke will be produced.

The method just described is contrary to the general rules for firing, but its philosophy is explained in the following: If a shovelful of coal is thrown on a bright fire by the spreading method, every particle of that coal is immediately subjected to the intense heat of the fire and the volatile matter is rapidly driven off. If this is followed by more coal, the result is a volume of volatile matter which is beyond the capacity of the furnace to handle without dense smoke.

If, on the other hand, the fuel is fired in a lump from the shovel without spreading, there is a considerable quantity of the coal which does not immediately become subjected to the high temperature. The coal on the outside of the pile gives up its volatile and the coal within is not affected until the volatile matter has been distilled from the outside lumps. Furthermore, the volatile matter from the inner portions of the pile must pass outward through the incandescent outer layer of fuel much in the same way as in the underfeed stoker. In this way the production of smoke can be retarded, and the more coal thrown on to the fire at once, the less smoke. Two shovelfuls of coal fired by the spreading method on a clean, bright fire will make more smoke than ten shovelfuls of coal fired by the lump method. In practice, it will be necessary to determine just how much coal should be fired at once, but six or eight shovelfuls on a side with the draft operated according to the method ordinarily used will be found to be about right.

When a battery of boilers is to be fired, the fires should be fed by the alternate method, as before, passing from one boiler to another until they are all charged and then repeating on the other side of the furnaces. It should be determined by experiment, however, just how many furnaces can be fired consecutively without producing dense smoke, and after this has once been made known, the fireman should adhere strictly to the rules laid down in this regard.

[It is to be remembered that Mr. Monnett is smoke inspector of Chicago and that the rules in the above, as well as the recommendations in the previous articles of this series, apply particularly to conditions in the region where they burn the soft Illinois coal which is high in volatile matter. Further, being smoke inspector, the author's principal effort is naturally toward smoke prevention, rather than economy or efficiency, which are more or less of second consideration.—Editor.]

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†Smoke inspector, city of Chicago.

Stopping Engine Rocking

By H. R. Low

On page 24 of POWER for July 1, 1913, readers were asked to consider the question: "Why Does the Engine Rock?" The responses were gratifying, for not only were they instructive and helpful, but ample evidence that engineers not only read POWER but think about what they read, and are not averse to imparting information that comes to them from their reading and thinking.

It may be of interest to learn that the rock has been eliminated. The method by which the cause of the trouble was found and results obtained was as follows: Indicator diagrams from both sides of the unit showing nothing radically wrong with the valve setting, some other cause had to be looked for. The belt was taken off and all four eccentrics, and both connecting-rods taken down. The quarter-box adjusting screws were slacked up, and the wheel marked and tried for balance. It was badly out. Examination showed the rim of the wheel to be $\frac{3}{16}$ in. thinner on one side than on the opposite. Four pieces of boiler iron were found secured to the rim by tap bolts, their total weight being 162 lb.

When these weights were put on, or by whom, no present employee at the plant has any recollection. It is supposed that they were put on by the builders to balance the wheel itself. Repeated trials resulted in the wheel coming to rest from any position with the chalk mark up, and the weights down. The weights were taken off and a marked improvement shown.

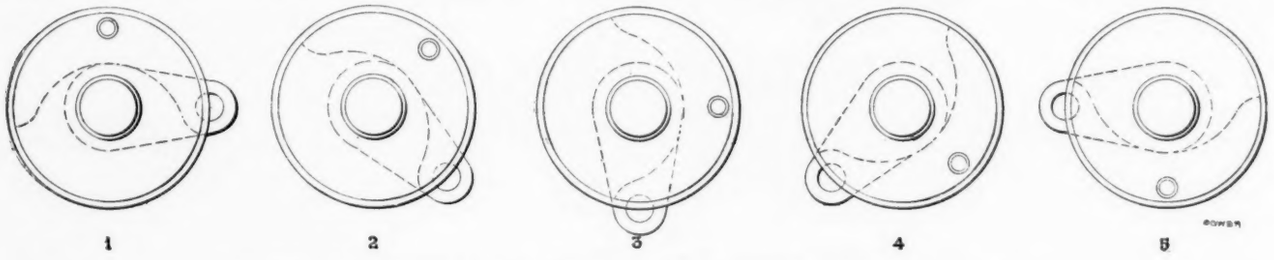
The engine was originally built with an arm crank on both sides, the crank on the small (16-in.) side having since been replaced by a disk crank. It was noticed that the position of the counterweight in this crank disk was on the same side of the center line of the shaft with the crank arm on the larger (20-in.) side, which had no counterweight at all; and when the difference in the weights of the two connecting-rods is considered it is seen that the larger rod with its boxes, strap, etc., tended to still further unbalance the unit. The illustrations showing the relative positions of the cranks and counterweight, and the positions they would assume for one-half revolution should make this clear.

The foundation, composed of brick and mortar with granite blocks under the cylinder, dummy stand and pillow block, had settled somewhat under the pillow block, throwing the greater part of the weight on two points, viz., the dummy-stand block and the front foot of the cylinder, the head end of the cylinder not bearing on its foot by 0.018 in. having broken the heads from four 1-in. bolts. It looked like a case of an unbalanced engine, and one out of alignment from a settled foundation. Evidently attempts had been made to stop the engine from rocking, as it was found that ¾-in. dowels had been put in between the cylinder feet and the cylinder casting, and two 1-in. tap bolts below the cylinder head, half in the cylinder casting and half in the rear foot.

The arm crank was split off by drilling a row of ⅞-in. holes across its face along the center line of the shaft and driving in four steel pins tapered ⅛ of an inch to 1 ft., and a disk crank ordered, having a suitable counterweight to replace it. The main shaft and wheel were raised and both bottom shells and quarter boxes taken out, and the shells rebabbitted. Jacks were placed under the cylinder and bed, and the cylinder feet and dummy-stand block removed, leaving the whole side resting on the jacks.

The foundation bolts were then taken out and thoroughly cleaned of oil and grease, and the holes burned out to remove as much oil as possible, so that the new grout would have a chance to unite with the foundation; channels, or gates being cut in the granite capstones to allow grout to be poured around the bolts after they were replaced and drawn up solidly.

The first move toward putting the engine together again was to square and level the bed with its mate. The feet and the dummy-stand block were next fitted to their positions, and foundation bolts replaced and drawn up and the engine again proved for alignment. Risers of brick and sand were built around the channels and thin grout poured in and allowed to dry out. The shaft was next let down into position, and the distance from the under side of the bearing to the pillow-block housing carefully measured, thus determining the amount of babbitt to be left in the bottom shell when bored. Then the shaft was bedded in and the new disk crank forced on.



STOPPING AN ENGINE FROM ROCKING—SHOWING DISK OUT OF BALANCE

Perhaps it might not be amiss at this time to call attention to the method of fitting side shells, or quarter boxes. Some engineers are content to roll a box on the journal and scrape according to the marks thus obtained, and when the box shows a good general bearing to call it good enough and let it go at that. This is a mistake. Shells are usually bored in sets, i.e., the side shells resting on the bottom-shell casting, the top shell resting on both side shells, this being the position when they are in service. When fitting side shells, instead of rolling them on the bearing they should be dropped carefully into place and moved lengthwise of the bearing for marks and fitted accordingly. There is usually end play enough to admit of this being done, and this comes nearer fitting a box in the position where it is to run.

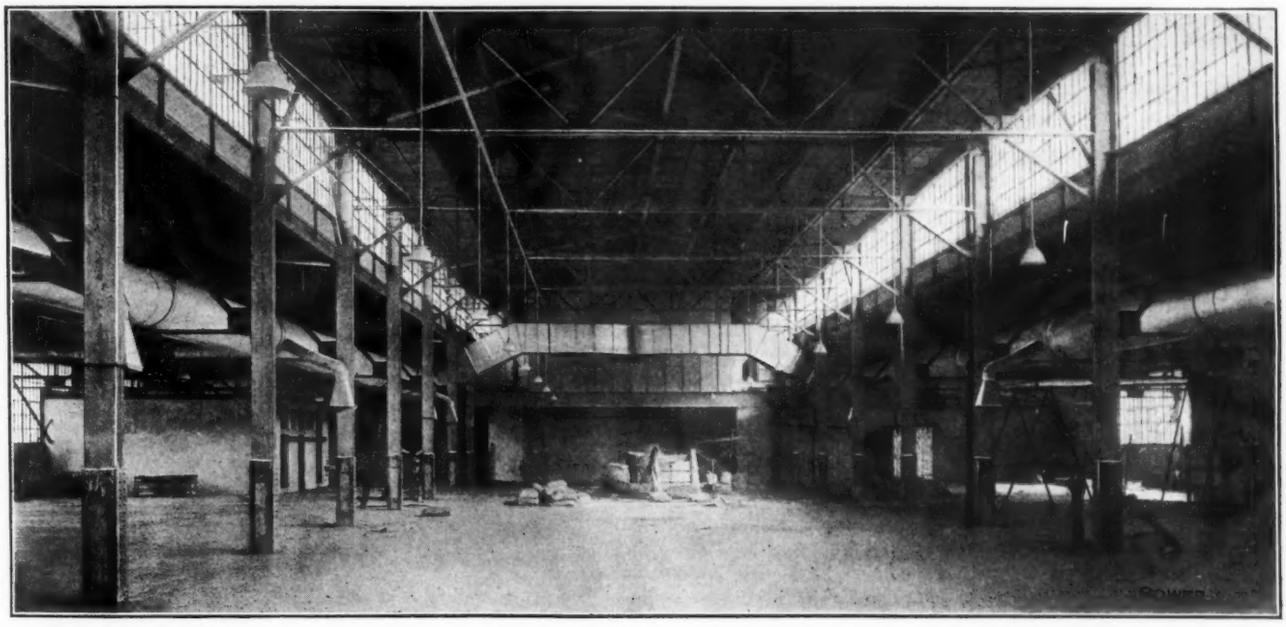
The crankpin boxes and eccentric straps were next looked after, requiring some scraping to restore alignment. Since making these changes the engine runs smoothly, for one 33 years old, and it is now possible to stand a nickel on edge on the steam-chest cover.

Heating the Largest Pier in the World

By Frank H. Jones

SYNOPSIS—Conditions of exposure and occupancy of the structure have offered unusual difficulties to the designers of this heating plant, and as the maximum demands are conjectural, considerable latitude of performance had be provided for.

Commonwealth Pier No. 5, at South Boston, Mass., now under construction by the State of Massachusetts, acting through the directors of the port of Boston, is the largest pier in existence. It is 1200 ft. long, 400 ft. wide, and of two-story steel and concrete construction. In addition to a magnificent headhouse containing the offices and warerooms, it has a floor area of about 900,000 sq.ft., nearly 700,000 sq.ft. being devoted to the handling of freight, which includes the entire first floor and the outer portions of the second floor. The remaining space provides for the passenger service and United States customs inspection.



Second Floor of Shed, Showing Warm-Air Ducts and Outlets

The heating and ventilation of so large a covered area, jutting out into the harbor and exposed on all sides, offered, at the outset, many difficulties to the designers, therefore the layout as installed is essentially an experiment. No one can predict with certainty what the demands on such a heating plant will be when under maximum operating conditions at different seasons of the year.

Its peculiar interest lies in the adoption of two systems of heating supplied from the same isolated plant of four large boilers run at low pressure. Steam heating by direct radiation is used in the headhouse and the offices of the pier, while a system of warming the sheds by steam-heated air under forced circulation by motor-driven fans through sheet-metal airways was adopted. An extension of the steam system was also made to piping for melting the snow and ice of the shed roof gutters.

Air Heating

The equipment for this service includes the following: Low-pressure steam and condensation mains from a reducing valve in the headhouse to the fan groups; all connections of these mains with the air heaters for both steam supply and condensation return; heaters of form, surface and capacity adapted to the special requirements; fans, motors with link-belt drive and all electrical wiring, apparatus and connections; sheet-metal construction work for the airways and fan chambers and from the fan chambers to the points of discharge and distribution of heated air; fan chambers, roof intakes and all airway accessories.

The steam for this system is delivered at the headhouse from the heating plant across Northern Ave. at practically boiler pressure. A reducing valve, with bypass of ample capacity for passing the maximum quantity of steam required by the entire steam service for the pier, is provided for reducing the pressure from about 50 lb. per sq.in for the high-pressure side to about 10 lb. per sq.in. on the low pressure. The condensation from all dry-valve house-heating pipes is discharged into the underground drainage system, and all traps are of the expansion type.

The air heaters of group No. 1, midway of the second floor of the shed, have a combined capacity for warming 70,000 cu.ft. of air per minute through a range of 60 deg. and with steam at 2 lb. gage pressure and with a velocity of air flow through the heater of 1000 ft. per min. Each of the heating coils of this group is divided

into five sections, each separate section being completely valved for separate use.

The heaters of group No. 2, at the harbor end of the pier, are similar to those of group No. 1, except that they have a combined capacity for warming 50,000 cu.ft. of air per minute through the same temperature range and under the same conditions as those of group No. 1.

Each section of the heaters is drained through a trap and air vented through a valve connected into the piping. The sizes of the traps and valves are proportioned solely by the surfaces of the several sections of the coil.

The fans are of the multivane, double-inlet type, of a capacity to move the air quantities required for the respective groups against a pressure of ¾-in. water column. The power input to the fans is specified as not to exceed 10 ft.-lb. per cu.ft. of air moved under conditions of maximum performance. The fans throughout are of metal and of construction suitable for marine service.

Twenty-five-horsepower variable-speed motors, with a speed control from 50 to 75 and 100 per cent. of full normal speed, drive the fans of each group.

The sheet-metal work for the airducts is of the best brand of galvanized iron throughout. U. S. gage No. 20 iron is used for all ducts of and above 16 sq.ft. in area; gage 22 for all sizes from 16 to 4 sq.ft., and gage 24 for smaller airways. All piping is braced and stiffened by small channel bars or angle-iron reënforcing where necessary.

The fan housings are mounted on the columns and iron ladders are dropped to the floor below for access to the platforms. The housings are constructed of 22-gage sheet metal on small angle-iron framework.

Direct radiation with vacuum is used for heating the offices of the first floor, and on the second floor the principal offices, the immigrants' detention rooms, doctors' rooms and inspector's quarters are also heated by this system. Cast-iron radiators are used, which it is specified shall weigh not less than 7 lb. per sq.ft.

All the pipes are so graded that the supply main slopes downward from the point of supply through the reducing valve to the extremity of the mains, and the return mains slope downward from their extremities to the point where connection is made with the main return to the pump room. The gradients are not less than one in 500. Hangers and other supports for all pipe work are constructed to admit of close adjustment for securing and maintaining the desired grade.

All piping under 10 in. is made up with screw joints, and at intervals of 150 ft. or less, flange joints are so placed as to facilitate the disconnection and replacing of any pipes without breaking the fittings. Expansion joints are provided by means of loops, circular bends, swivel joints and, in some cases, slip joints.

Where water and sanitary piping are run in places exposed to the danger of freezing, the steam pipes or condensation pipes are run along beside them or wrapped with them. Where such pipes are run for the sole purpose of protection, they are drained through expansion traps to the nearest connection with the return main where possible; otherwise, to the sewer.

All return mains within the shed are run above the ground back to the headhouse on account of the uncertainty of stability were they placed underground in the new earth fill.

For the melting of gutter ice and snow, pipes are run for blowing steam into the gutters of the lower sheds. These pipes run in the gutters and are perforated along their bottom lines with ⅛-in. holes spaced 12 in. on centers, the pipes being suspended 3 to 5 in. above the bottom of the gutters. The area of the pipeways for this service is not less than 1 sq.in. for every 80 holes.

The heating plant is a 55x90-ft., one-story brick structure across Northern Ave. from the pier. Steam service and return mains are run on overhead supports close to the viaduct leading to the second story of the pier.

Four 72 in. by 21 ft. 6 in. horizontal return-tubular boilers constitute the heating battery, and provision has been made for the addition of another similar unit should the operating conditions warrant. The settings are arranged in a single battery, with an air space between each pair of settings.

The boilers were designed for high pressure in anticipation of a possible installation of an electric-power plant, though it is expected that 100 lb. pressure will be suitable for the maximum service of the heating plant and that 60 lb. pressure will be adequate for all average requirements.

The Efficiency Engineer

By Joseph Harrington

Much is heard of efficiency engineering in these days, and the term has come to be applied to a number of varieties of engineering effort. Like most engineering subjects, efficiency work has been divided and subdivided until it is now necessary to indicate what kind of labor or operation is included in the engineer's particular department.

One of the most fertile fields of the expert is that relating to the economical use of coal. Of late years there has been a nation-wide campaign for smokeless chimneys, resulting in a rather extended knowledge of the basic principles of economic combustion and an undoubted improvement in the art of burning coal. It is probably true that there is no single operation in the whole system of human activity that is so universally encountered and so fundamentally necessary to the prosperity of the race as the development of power by means of the steam boiler. Transportation, mining and manufacture derive their first impulse from the expansive energy of steam, yet the amount of useful work that can be extracted from the black and innocent lump of coal is pitifully small. All but a small percentage is dissipated in one form or another. Energy enough to do the work of the world is passing to waste up the stacks of countless boiler rooms.

In these days of psychological influence, it is interesting to analyze the analyzer, or, in other words, to examine the present-day efficiency engineer and see what breed of man he is and what kind of atmosphere surrounds his daily work. What are the tools of his trade and what is the raw material upon which he tries to leave his impress?

Combustion engineering is in a transition stage, and "a little knowledge is a dangerous thing" 'applies with tremendous force and underlies most of the woes of the expert. Scarcely a watch engineer and boiler-room foreman but has read the technical press and informed himself to some extent of the requirements for efficient com-

bustion. Also, and much more to the point, these same folks have formed opinions regarding their particular furnace, boiler or stoker which are most frequently inflexible, indestructible and eternally enduring. It takes a man who has fathered a furnace design and made it work to exemplify the fullness of parental love.

"What business," he exclaims, "has any man to come in here and even insinuate that anything could be better than this child of my engineering skill!" How can the real expert, with the experience of a thousand trials behind him, convince this man that his design is not up to standard, and that he should earnestly coöperate with the expert in proving that he is out of touch with the times?

And yet, in principle and in effect, this is exactly the situation that has to be met and overcome. Above all things, the engineer must have the cordial assistance of the operating force and their true and genuine coöperation in his endeavor to work out the admittedly difficult problems of the boiler room.

Arbitrary commands result first in creating a natural feeling of resentment. Besides a sound and thorough knowledge of his business, the efficiency engineer must then have tact. He must be broad enough to see the good in the other fellow's way and freely admit it, yet he must steadily press home his own good arguments in a way that will not offend. He must be a teacher, having the faculty of imparting knowledge in an interesting way. He has to be a keen judge of human nature, so as to adapt his manner of presentation to the comprehension and prejudices of his hearer.

First, education, and then incentive is necessary. More than one promising career has encountered the frosts of adversity because the fireman took no interest in his duties, and dropped all the carefully planned work as soon as the novelty wore off. It is all right for "the boss" to work nights, but the fireman's interest stops with the pay envelope. That is what he is working for, and the sooner this is generally recognized, the better for "the boss." As to the combustion expert, if one foot rests on knowledge, the other certainly rests on interest. All the skill at his command is required to create this feeling. All his art and all his judgment find room for exercise. He must secure in some way that element of personal interest that is the mainspring of sustained action. Efficiency in the boiler room is so much the result of skillful firing that the best-planned plant will give poor results if that skillful operation is lacking.

Direct Current vs. Three-Phase System for Isolated Plants

By E. M. Marshall

SYNOPSIS—An analysis showing the direct-current, three-wire system to be superior in most cases for this class of service.

With the rapid extension of alternating-current operation and the installation of single-phase and three-phase systems where electricity is purchased from a central station, there is a tendency to overlook some of the engineering involved when the small-plant management takes up the installation of an isolated-plant equipment. The alternating-current system is sometimes accepted when there are decided arguments in favor of direct current. The direct-current three-wire generator came into use some half dozen years ago, at about the time that power companies began active work for industrial motor loads, and has in many respects not been given the consideration that its design and operation deserve. In what follows the writer desires to present a few considerations that seem pertinent and deserving of serious thought when designing and laying out industrial-plant wiring to be supplied from an isolated plant.

Assume that the plant is of average size, with a demand for motors ranging from 2 to 25 hp. and a lighting service of not more than 20 per cent. of the total light and power load. For such a system the wiring and motor costs are important factors. In the first place, the requirements of the National Electric Code are an important although often neglected consideration in favor of the direct-current system, as will be shown. It is generally known that the National Electric Code requires that lighting circuits must be arranged so that one cutout will not be called upon for more than 660 watts. For the direct-current three-wire circuits, shown diagrammatically in Fig. 1, voltages of 110 and 220 are considered. The maximum allowable current per branch of the feeder circuit is then

$$watts \div voltage = 660 \div 110 = 6 \ amperes$$

and eleven 60-watt lamps may be used in each side of the circuit, or 22 lamps from one cutout.

With the three-phase circuit, Fig. 2, an arrangement of 11 lamps per phase violates the code ruling mentioned, for thirty-three 60-watt lamps on one cutout would represent 1980 watts. This, then, would call for a wattage per circuit on a balanced noninductive load of $I \times E \times 1.732$, or for a circuit of 33 lamps it represents a current of $1980 \div (110 \times 1.732) = 10.38$ amperes. And each fuse of each leg must be subject to frequent blowing if the circuit is used to maximum capacity as shown and 10-ampere fuses are installed. Also, if the underwriter's inspection is rigid, such an arrangement may not be approved.

If it is rigidly interpreted, that 6 amperes limits the current per branch, then for the three-phase circuits only $6 \times 110 \times 1.732 = 1143$ watts per three-phase circuit can be used, or a total of $1143 \div 60 = 19$ lamps, as against 22 for the direct-current three-wire circuit. With an arrangement of six lamps per phase, the current per phase would be $(3 \times 6 \times 60) \div (110 \times 1.732) = 5.6$ amperes, and the installation would pass inspection.

There seems to be some question as to the code ruling on this point of current-limiting feature. However, it is plain that a current of 6 amperes, if used as the limit in a direct-current system, should likewise be the limit for three-phase installations, where only 660 watts are allowed on one cutout. It is plain from Fig. 1 that this is the case for the direct-current circuit, for, as shown,

this circuit is protected by a three-pole fuse block with fuses at *A*, *B* and *C*, and when each fuse has a normal capacity of 6 amperes, the circuit will not be interrupted. So long as an equal number of lamps remains in circuit in each side, a balanced condition exists, and no current flows through fuse *B*, and it can be removed without interruption of the circuit. Under the same conditions, however, if the fuse *A* is removed, the lights on that side of the circuit will go out and the fuse *B* is called upon to complete the other side of the circuit. This fuse *B*

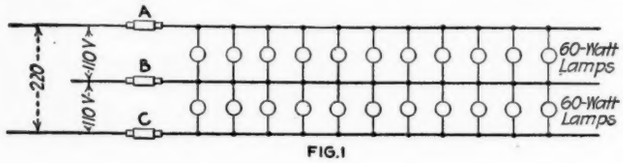


FIG. 1

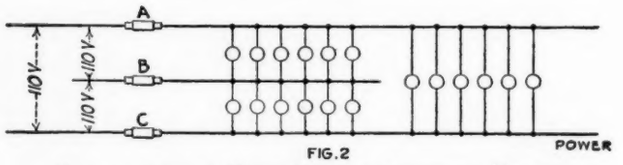


FIG. 2

POWER

FIG. 1. THREE-WIRE DIRECT-CURRENT CIRCUIT
FIG. 2. THREE-WIRE THREE-PHASE CIRCUIT

together with fuse *C* comprises a cutout in the interpretation of the code serving eleven 60-watt lamps at 110 volts, or 660 watts.

Consider now the three-phase circuit of Fig. 2, which is also protected by a three-pole fuse block, and shown with six 60-watt lamps per phase, or a total of 18 lamps. If the code were to rule specifically that 660 watts be allowable between any pair of wires in a system, then an arrangement of 11 lamps per phase could not be questioned. With an arrangement of six lamps per phase as shown, however, there is a current per phase of $(3 \times 6 \times 60) \div (110 \times 1.73) = 5.6$ amperes. So that if fuse *B* was removed with all the lamps burning, a two-wire circuit would exist with six lamps burning at 110 volts and six series of two lamps on 110 volts. The six lamps on 110 volts would require $(6 \times 60) \div 110 = 3.2$ amperes, and the six sets of two lamps in

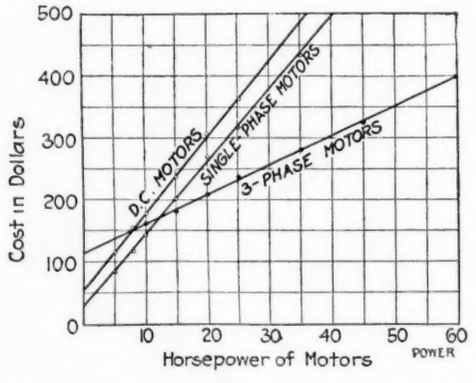


FIG. 3. RELATIVE COSTS OF DIRECT- AND ALTERNATING-CURRENT MOTORS

series burning at about half voltage would require 2.1 amperes, so that the current passing fuses *A* and *C* would then be 3.2 + 2.1, or 5.3 amperes.

From this consideration the usual interpretation of the code that 6 amperes is the limiting feature in any circuit is substantiated, and consequently only 18 lamps can be used from one cutout on a three-phase circuit, while 22 lamps can be used on a three-wire direct-current circuit from one cutout.

Again, if the copper required for a two-wire system is taken at 100 per cent., that for the three-wire direct-current system would be 37.5 per cent. with all three wires the same size, while that for the three-phase system would be 75 per cent.

As to generator cost, the direct-current power-plant equipment will just about balance the cost of alternating-current equipment, and in no case will be more than 10 or 15 per cent. greater when no transformers are required for the alternating-current layout. The data curves in Fig. 3 give the relative cost of motors for direct-current, single- and three-phase systems, showing that for a plant where a large number of small motors are used, say none larger than 12 or 15 hp., the direct-current installation compares favorably as to first cost of equipment.

Reactive Interpole Shunt

BY GORDON FOX

The function of the interpole in direct-current motors and generators is to provide for good commutation, not only at partial load and full load, but also upon overloads. The interpole has been found particularly effective when applied to motors driving machines having wide load fluctuations, and is likewise effective when used upon generators subject to frequently changing loads such as are met in railway work and mines.

Fluctuations in load upon machines of this kind are often very rapid. Since the interpole winding is of inductive character, these changes in load current and consequent magnetic intensity in the interpole winding tend to set up self-induced electromotive forces in the interpole circuit.

Most interpole windings are designed so that they will be stronger than necessary. Then they are shunted with german-silver resistance wire or ribbon until the proper strength is obtained to maintain a fixed neutral at all loads. Thus there are two parallel paths for the load current, one through the interpole windings, the other through the german-silver shunt. One of these circuits is momentarily inductive, the other is noninductive; hence, when rapid load changes occur, the inductance of the interpole winding causes it to lag in responding to the changes. If a sudden increase in load occurs, the interpole inductance causes more than the proper proportion of the current to flow momentarily through the noninductive shunt, making the interpole strength momentarily less than it should be, and sparking or flashing is likely to occur for an instant. With frequently and suddenly changing loads, the interpole will thus fail to adjust itself quickly to the changed conditions and sparking will occur with each change.

If the german-silver shunt around the interpole be also inductive, as much or more so than the interpole, then sudden load changes will be properly divided, as though both windings were noninductive. It is hardly necessary to obtain an exact inductive relationship, but it is well to wind the interpole shunt upon an iron core so that it will have sufficient inductance to cause the main interpole winding to assume instantly its portion of changes of load.

Comparing Power-Plant Efficiencies

By Morgan B. Smith

SYNOPSIS—Pounds of coal burned vs. B.t.u. per kilowatt-hour generated.

There seems to be a fairly general lack of appreciation in many power plants of the real relation that exists between the fuel consumed and the current generated. Too many by far of our plants are content to figure the relation in terms of mere pounds of fuel vs. current generated, losing sight altogether of the amount of actual heat supplied per unit of current. That it is a fallacy to speak of fuel in terms of mere weight is now recognized as a fact and that it is true that the fuel should be considered as so much available heat energy is equally well known.

It is with the idea of making plain the above fallacy that the following four power plants are compared, figuring their relative efficiencies in terms of pounds of coal per kilowatt-hour and in terms of B.t.u. per kilowatt-hour, showing that these plants should be rated in terms of heat supplied per kilowatt-hour generated rather than in terms of mere weight of coal consumed.

These four plants are operating on four decidedly different coals, the analyses of which are given in Table 1.

TABLE 1. ANALYSIS OF THE FOUR COALS

Plant No.	Coal Used	B.t.u.	Ash	Fixed Carbon	Volatile	Sulphur	H_2O
1	Boomer	14,070	8.4	61.65	28.60	1.00	6.85
2	H. V. slack	12,190	13.5	52.40	36.00	2.00	8.00
3	Illinois	9,639	13.50	41.00	32.00	4.80	15.80
4	Texas	7,218	7.75	32.00	28.50	0.80	34.10

The four plants are of about the same capacity and are operating under almost identical conditions. For the sake of comparison, plants 1 and 2 will be considered together and plants 3 and 4 in turn in the same manner, showing data covering the period January to June. The charts attached show graphically these same figures.

TABLE 2. COMPARATIVE DATA FROM PLANTS 1 AND 2

Plant	Coal	Month	Av. Fuel B.t.u.	Kw.-Hr. Av.	Lb. Coal per Kw.-Hr.	B.t.u. per Kw.-Hr.	Kw.-Hr. per Million B.t.u.
1	Boomer	Jan.	14,000	960,700	3.55	49,000	20.40
		Feb.	14,100	985,960	3.50	49,350	20.25
		Mar.	13,980	999,870	3.62	50,608	19.75
		Apr.	14,160	1,000,060	3.52	50,268	19.85
		May	14,100	1,000,360	3.45	48,645	20.51
		June	14,080	1,000,800	3.42	48,134	20.80
		Av.	14,070	991,292	3.507	49,334	20.26
2	H. V. slack	Jan.	12,250	975,600	4.10	50,225	19.90
		Feb.	12,400	980,700	3.96	49,104	20.35
		Mar.	12,100	1,000,060	4.00	48,400	20.62
		Apr.	12,090	1,000,030	4.05	48,965	20.40
		May	12,350	1,001,080	3.92	48,412	20.62
		June	11,950	1,001,350	4.21	50,310	19.87
		Av.	12,190	993,303	4.04	49,236	20,293

Comparing the above averages it will be noticed that the loads carried are almost the same; that the pounds of coal consumed per unit of current generated vary widely; that in spite of the variance in the weight of fuel consumed the actual heat utilized per unit of current generated at the two stations agrees within small limits.

If the relative efficiencies of these two stations were to be judged in the old manner, namely, in terms of weight of fuel only, it would be concluded that plant No. 1 is operating at considerably higher efficiency than plant No. 2. Judging them in terms of heat utilized per unit of current generated the conclusion would be that the two plants are operating at about the same degree of efficiency.

As a matter of fact, plant No. 2 is actually operating under more adverse conditions and so is to be rated at least even with plant No. 1 if not actually above it. Plant No. 2 is handling more coal and more ash than plant No. 1 to generate the same amount of electrical energy. Plant No. 2 is splendidly equipped for handling both coal and ashes so that the cost for handling is kept at a minimum, although still higher than in the case of plant No. 1.

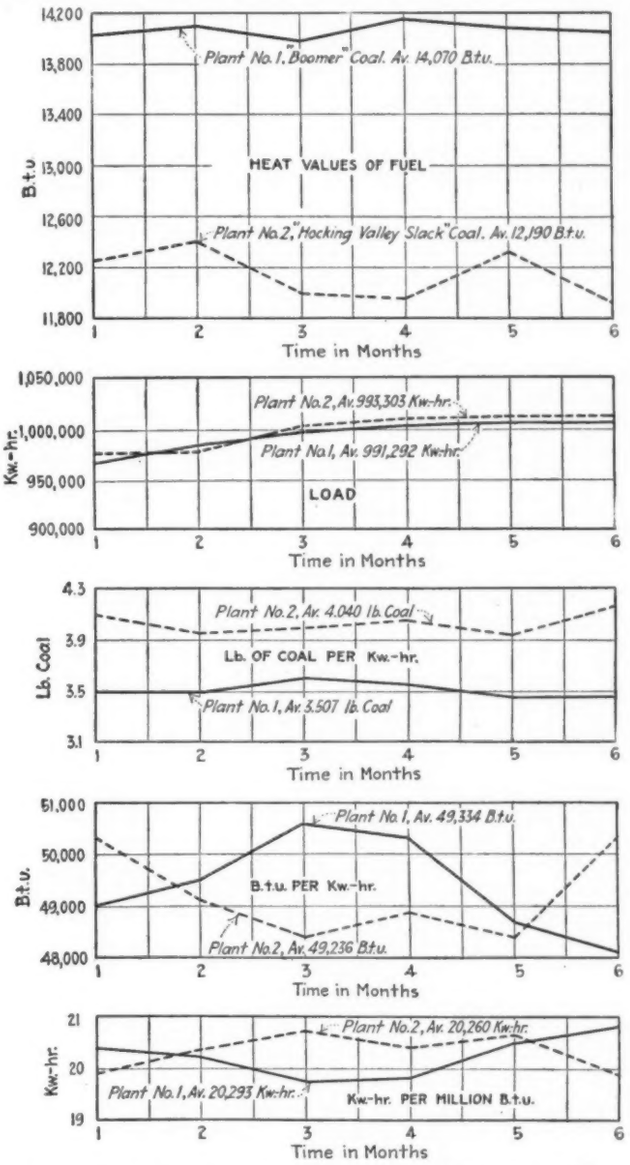

Plant No. 1, "Boomer" Coal. Av. 14,070 B.t.u.
HEAT VALUES OF FUEL
Plant No. 2, "Hocking Valley Slack" Coal. Av. 12,190 B.t.u.
B.t.u.
Time in Months
Plant No. 2, Av. 993,303 Kw-hr.
Plant No. 1, Av. 991,292 Kw-hr.
LOAD
Kw.-hr.
Plant No. 2, Av. 4.040 lb. Coal
Lb. OF COAL PER Kw.-hr.
Plant No. 1, Av. 3.507 lb. Coal
Lb. Coal
Plant No. 1, Av. 49,334 B.t.u.
B.t.u. PER Kw.-hr.
Plant No. 2, Av. 49,236 B.t.u.
Plant No. 2, Av. 20,260 Kw-hr.
Plant No. 1, Av. 20,293 Kw-hr.
Kw-hr. PER MILLION B.t.u.

Fig. 1. Graphical Indication of Results from Plants 1 and 2

Plants 3 and 4 are operating on fuels which vary more widely than those utilized in plants 1 and 2, and the loads carried are not so nearly alike. Plant No. 3 has two factors to contend with, both of which tend to lower efficiency, namely, a lower load and a poorer coal for fuel,

compared with plant No. 4. In spite of this the two plants are operating at about the same degree of efficiency.

Data on these two plants for the period January to June show the results given in Table 3. These are also shown graphically in Fig. 2.

In this case the difference in weight of fuel consumed

TABLE 3. A COMPARISON OF PLANTS 3 AND 4

Plant	Coal	Month	Av. Fuel B.t.u.	Kw.-Hr. Av.	Lb. Coal per Kw.-Hr.	B.t.u. per Kw.-Hr.	Kw.-Hr. per Million B.t.u.
3	Illinois	Jan.	9,149	967,800	5.68	51,966	19.22
		Feb.	9,319	980,700	5.45	50,789	19.65
		Mar.	9,983	1,000,700	5.30	52,910	18.90
		Apr.	9,790	999,980	5.37	52,572	19.00
		May	9,655	1,000,150	5.41	52,234	19.13
		June	9,940	1,001,350	5.33	52,980	18.85
		Av.	9,639	991,780	5.42	52,242	19.125
4	Texas	Jan.	7,110	867,000	7.31	51,974	19.25
		Feb.	7,360	910,000	7.25	53,360	18.75
		Mar.	7,080	889,700	7.50	53,100	18.80
		Apr.	7,180	993,450	7.35	52,773	18.95
		May	7,400	900,160	7.28	53,872	18.55
		June	7,180	913,700	7.32	52,558	19.05
		Av.	7.218	895,660	7.33	52,939	18.89

per kilowatt-hour generated is about 2 lb., yet when the heat value of the two fuels is considered it is found that these two plants are running at nearly the same efficiency.

In considering each of these four plants only the heat values of the fuels in relation to the load carried have been taken up. There are other factors to be considered in the final judgment of efficiency, such as coal and ash handling, wear and tear on equipment, etc. With these we are not now concerned; they must work themselves out to the best advantage in each case. It may be of interest to state that in the four plants mentioned the fuels were all mechanically stoked. Plants 1 and 2 had overfeed grates; plant 3 being underfed and plant 4 being fitted with chain grates.

The general performances of these plants represent in a remarkable degree the average efficiency of many of our power plants. They show the wide errors into which operating engineers may be led in judging the performance of a plant without first knowing all the conditions. This is especially true in the matter of the relation of the fuel used vs. the current generated.

It was just such a misapprehension of facts that led the writer to give the facts relative to plants 1 and 2 and to supplement these with figures on plants 3 and 4. The statement had been made that plant No. 1 showed a much better performance than did plant No. 2, the speaker going so far as to criticize plant No. 2 severely. Investigation brought out the facts given above and at once stopped all criticism of the No. 2 plant. It also showed that plant No. 1 was not doing as well as it had first seemed.

It often happens that, although truth hurts at times, it really does no end of good in power-plant practice, for it gives facts to work upon. Guesswork takes a back seat and stays there.

As a matter of fact, the four plants are doing about the same, although the weight of fuel burned per unit of current generated varies all the way from 3.5 lb. to 7.33 lb. of coal per kw.-hr. generated. The B.t.u. supplied vary only from 49,334 to 52,939 per kw.-hr. generated, a variance not at all in proportion to the difference in the weight of fuel burned.

Finally, when speaking of fuel consumed, be sure to know the exact nature of the fuel in question; also know the load carried; for these two factors are preëminently

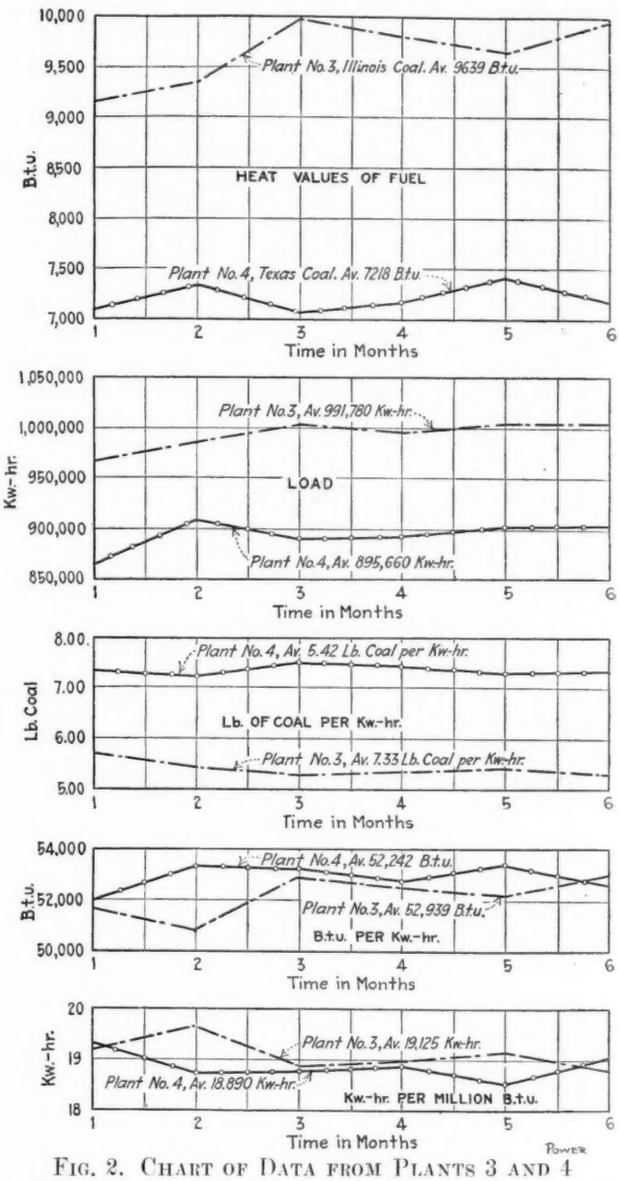


FIG. 2. CHART OF DATA FROM PLANTS 3 AND 4

important in arriving at a just measure of a power plant's efficiency.

Some Characteristics of Water—Water is at its maximum density (weight) at 39.1 degrees F. From this temperature it expands by heat or cold. A vessel levelfull of water at this temperature will overflow if the water is either heated or cooled. When formed into ice at 32 deg. it will have expanded one-twelfth ($^1/_{12}$) of its original bulk (at 39.1 deg.). The weight of 1 cu.ft. of ice at 32 deg. and that of 1 cu.ft. of water at 300 deg. will be nearly the same, 57.2 to 57.5. Water at 60 deg. weighs 62.35 lb. per cu.ft. For ordinary calculations, 62½ is sufficiently accurate. Water evaporates at all temperatures. It dissolves more substances than any other known substance. Water has a greater capacity for heat than any other known substance.

Oklahoma Breaks Coal Record—Coal as mined in Oklahoma in 1913 to the amount of 4,165,770 short tons, valued at $8,542,748, both record-breaking totals for the state, according to figures compiled by E. W. Parker, of the United States Geological Survey, in coöperation with the Oklahoma Geological Survey.

Editorials

Conserving Niagara

Prospect of action by Congress in the matter revives the agitation of the controversy over Niagara Falls. Which way shall they be conserved, for their scenic beauty or for their power? There are rabid partisans on both sides of the question. At the one extreme are those who want the Falls restored to their pristine glory, and the power houses and all evidences of sordid mankind removed, while extremists of the opposite kind will not be happy so long as a drop of water is unutilized for power generation.

So compelling are the arguments on both sides of the question that it is difficult for one not yet committed to either side to decide just where he will stand, and for the present we are trying to keep in the middle and agree with everybody. We are pained at the thought of any impairment of the beauty and grandeur of the cataract, but at the same time, as engineers, we hate to think of the extravagant waste of power just for a spectacle. When the question of affecting navigation comes in there is no room for argument. Shipping on the Great Lakes is too important to be subserved even to power production.

Nothing is much more imposing and impressive than a conflagration, but we call anyone who sets destructive fires so as to see the flames an incendiary, or firebug—an enemy to society. No properly balanced person would advise the ruthless burning of hundreds of thousands of tons of coal to make a huge bonfire and keep it going for the benefit of tourists. Sometimes an oil tank or a mine takes fire accidentally and people travel great distances to see the blaze, but those whose money is going up in the smoke spare no effort to extinguish the fire.

In a sense, every undeveloped water-power is a burning coal mine, for coal of the equivalent power would be saved if the water-power were utilized, and by just so much would the exhaustion of coal be postponed.

We think that if we owned Niagara we would feel that we were paying pretty heavily to entertain the public if we continued to let the water flow over the edge instead of down penstocks. Merely because we hold no stock in the Falls is no excuse for our being so selfish as not to care how much water is wasted. As a state or national property, the Falls belongs to the taxpayers and they are all chipping in their mite to maintain a world's attraction, all of which may be very commendable.

Again, we picture our descendants shivering in the cruel winter for want of coal to make a fire, and can hear their condemnation at our extravagance which hastened the time of their suffering. Is it fair to gratify our eyes and our sense of the beautiful at the expense of the actual comfort of others? True, it may seem like borrowing trouble to be worrying about our many-times-great-grand-children, like the old maid, who was crying because "s'posin' she got married, an' had a child and it should die." There may be as many and as remote chances that the dire consequences will be averted. Heat made by electricity, in turn hydraulically generated, may be cheaper than coal before so very long, or other ways found to keep our surroundings at temperate temperatures.

So we have reasoned back to where we started and can only conclude that we must decide whether "the game is worth the candle." Let us have all the show we can for the least money; let us take water from the Falls until their beauty would be hurt more than the extra power would be worth, and let us leave as much water as we can afford to throw away.

After all, we are not inconsistently prodigal so long as we burn up coal as we do for unnecessary illumination of our "White Ways" and for night advertising signs.

Harmony between Employer and Engineer

In the last issue we referred editorially to what we termed "business grease." This had reference to the sort of relations between buyer and seller that are lubricants in the sense of eliminating friction between the producer and the consumer.

The thought is appropriately extended in the cartoon of this week, entitled, "A Smooth Running Bearing," typifying the employer and engineer as the two boxes in a rod end. Correct engine-room management is the force driving up the key of efficiency to take out the knocks in the bearing and adjust the boxes to a nice running fit on the journal. Finally, the oil of harmony, coming by way of the employer, as it should, completes the provision of the necessary conditions for "a smooth running bearing."

The more one studies this picture the further the aptness of the analogy will be seen to extend. In his management of the engine room, the engineer must not be too aggressive nor bring unnecessary pressure to bear on the employer, so that he will become hot, for the engineer will feel the effects of this himself.

A little thing not to be overlooked is the importance of shims between the boxes. This might suggest that there should not be too much intimacy between the employer and the engineer, or, at any rate, that they should be kept apart enough not to interfere with each other. The employer should not meddle with the engineer in the latter's conduct of the engine room; no more should the engineer attempt to tell the employer how to run his business.

When the bearing is first assembled the boxes must be scraped until there is good contact with the journal. Obviously, it is true also that the employer and the engineer must each be well fitted to his place if things are to continue to go smoothly. While the boxes are new and until the engineer and the employer become acquainted and accustomed to one another, it is well to run a little

slow, watching for necessary changes of adjustment and not putting on too much load until these two members have worn into place.

Again, how useless would be the bearing without either box! The employer cannot operate his plant without the engineer and the engineer has no plant to operate without the employer. If this interdependence were not so often overlooked or forgotten, there would be less discontent on both sides, for then there would be more effort to coöperate.

In the natural order of things the employer is on top and the engineer on the bottom, but they get equal shares of the load, and they have their ups and downs together.

The boxes must be of the right composition according to the service to be rendered and the men, too, must be made of the right stuff to do what is expected of them.

And so the comparison might be extended indefinitely, but enough has been said to emphasize the need of the employer and the engineer working together, each doing his part.

Overloaded Stacks Due to Excess Air

Of all the many things with which the engineer has to deal, air is one of the most common and one of the most important. For the successful and economical combustion of fuel, it must be supplied in quantities which are not ordinarily easy to determine. In most plants, the quantities supplied are greatly in excess of those practically required.

This brings up the interesting question: How many flues and stacks are overloaded, condemned as of inadequate capacity because they are required to pass such great quantities of excess air? Every pound of air that goes into the furnace must be passed by the flue and stack. Both have a limit to their capacities, just as has a pipe line carrying water, air or any other medium. Plant designers are often accused of making flues and stacks too small for overload condition. There may be numerous places where this condition prevails, but it seems evident that in many plants so called overloaded flues and stacks are overloaded with too great an excess of air which never should have entered the furnace.

Uniform Boiler Specifications

The outlook is bright for an interesting session at the public hearing called for Sept. 15 by the Committee on Standard Boiler Specifications of the American Society of Mechanical Engineers. At the annual meeting of the American Boiler Manufacturers Association, to be held the first week in September, the subject of uniform boiler specifications will be discussed, and it is more than likely that there will be developed some very definite propositions to be submitted at the later meeting, to which all interested in the subject are invited.

The occasion of the agitation is the present deplorable lack of uniformity, not to say consistency, between the laws and regulations now in effect in the various states and cities governing the construction and operation of boilers. There is no disposition to rebel against laws that make for greater safety in the handling of steam-plant equipment; quite the reverse, for it is to the interest of all parties concerned—manufacturers, owners and users—to decrease the attendant danger, but it is important to eliminate, so far as possible, unnecessary requirements which are at variance in different localities, for they are embarrassing to the manufacturer and the source of needless expense to the purchaser.

It was the expectation that the question would be widely discussed at the spring meeting of the mechanical engineers in St. Paul and Minneapolis, but, by action of the council, the discussion was so restricted in its latitude that little of value was brought out. As a consequence, this meeting in New York was decided upon as an individual undertaking of the committee, so that the views of all concerned might be brought out.

In the meantime, suggestions and criticisms have been asked, to be submitted in writing not later than Aug. 15. The evidences of interest which are being manifested in all quarters indicate that the meeting will be much more largely attended and of greater significance than even the committee anticipated, and the prospect is encouraging for accomplishment of the big purpose which has grown out of the committee's original work.

The meeting will be held in the Engineering Societies Building, 29 West 39th St., New York City, at 10 in the forenoon of Sept. 15. Thereafter the committee will present its report for discussion at the annual meeting of the society in December.

Panama Boiler-Inspection Rules

Rules for the inspection of stationary boilers operating in the Canal Zone have just been issued by an executive order of Gov. Goethals. A study of these regulations would indicate that the Massachusetts rules had been consulted, although more attention is paid to the inspection and to fittings and less to the actual construction of the boiler itself. This is as might be expected, for it is improbable that any boilers will be built in Panama.

Annual internal inspections and hydrostatic tests are prescribed, preferably six months apart, and whenever flues are removed from a boiler, those in charge must notify the inspection service, so that an internal inspection may be made. With regard to the care to be exercised in making the internal inspection, the rules say:

> The entire interior of the boiler, where accessible, must be examined for cracks, pitting and grooving. The edges of plates, laps, seams and joints where cracks and defects are likely to develop and any defects which an external examination may have indicated, must be given especially careful examination. . . . Boilers having lap-joint longitudinal seams shall be examined with care to detect grooving and cracks at the edges of seams, and any sheets showing such cracks shall be condemned for service and not repaired.

From the foregoing precautions, it is evident that the mechanical department of the Canal Government, which formulated the rules, has been a keen observer of recent boiler explosions.

Of equal importance with the rules pertaining to inspection are those providing for the care and safe operation of boilers, the idea being that the fireman, by adopting precautionary measures, can do as much, if not more, than the inspector to prevent boiler failures. In this connection, the fireman is warned not to draw the fires in case of low water, but to immediately cover them with ashes or fresh coal and close the ashpit doors. We are glad to see this point emphasized, as it would undoubtedly be the first impulse of many firemen under such circumstances to draw the fires, whereas this is likely to intensify the heat and make matters worse.

Correspondence

A Boiler Test

I am interested in the comparative boiler test conducted by C. R. McGahey, as published on p. 21, July 7, and note the increased evaporation from 7.99 on the test without the steam jets to 8.25 with them. It has not been stated whether the steam available for commercial purposes per pound of coal was greater when using the steam jets, which would be necessary to demonstrate that there was a saving of about "31 lb. of coal to the thousand pounds burned."

It would be instructive to know the number and diameter of the steam jets, the length of time they were on, and whether they were throttled. This would be an approximate guide as to what proportion of the increased boiler horsepower (144 against 127.25) is chargeable to the operation and if the final result will show any net saving in coal.

J. D. MacLean.

Toronto, Ont., Can.

The conditions were the same on running the boiler test as for output. The steam for maintaining the jets was taken from the boiler under test, and there were four jets used, having a nozzle with an opening $\frac{1}{16}$ in. diameter. These were taken from the flue blowing pipe and had but one control valve. This was only slightly open, and therefore throttled the supply. My version of the matter is that the difference is due to the increased draft conditions, which were clearly set forth, so that it could be seen that this was the true state. There could be no gain from the use of steam above the fire.

C. R. McGahey.

Baltimore, Md.

Preheating Furnace Air

M. A. Olmstead's letter on this subject on page 24, July 7, surprised me in the high saving (15 per cent.) which he believes he is making. While this amount is well worth saving, there are, however, some facts that should be considered before going to much expense in special equipment—i.e., the principles involved. For example, one pound of Kansas coal has on an average 12,500 B.t.u. and under running conditions 17 pounds of air per pound of coal is used, so that the products of combustion per pound of coal will be 18 lb., a useful approximate number to remember.

When the air is fed in the usual way, we can, without much error, assume it to be 80 deg. Raised to 190 deg. by the preheater, the specific heat of air at this temperature is about 0.237, therefore the heat absorbed is

$$17\ lb. \times 110\ deg. \times 0.237 = 443\ B.t.u.$$

Under these conditions, the one pound of 12,500 B.t.u. coal, together with the air, supplies 12,943 B.t.u. Thus, to make the same amount of steam as before, we would require only

$$\frac{12,500}{12,943} = 0.965\ lb.$$

of coal where one pound was used before. This would be a saving of

$$1 - 0.965 = 0.035\ lb.$$

or 3.5 per cent., which shows that the greater part of the saving must be due to other causes. It would be interesting to learn more of the particulars.

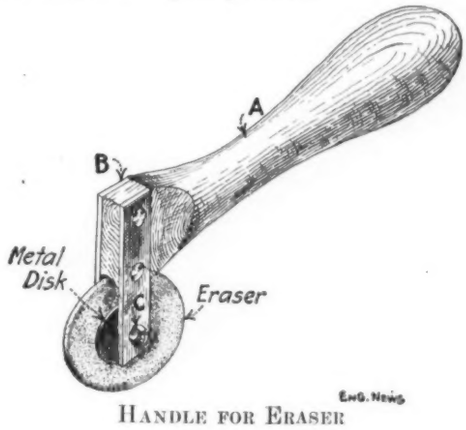
G. P. Pearce.

Moline, Ill.

Drafting Kink

A description of this eraser handle was published in the *Engineering News*, of June 11, and may prove of interest to readers of Power.

The handle *A* is of wood, to the end of which the metal strips (preferably copper or brass) *B* are fastened, as shown. The small bolt through the ends of the strips clamps the eraser firmly in position.



Handle for Eraser

Anyone having occasion to use a circular eraser frequently will appreciate the relief from injury to the fingers and the fact that the eraser may be used after the metal disks have been removed.

John E. Cahill, Jr.

New York City.

Machinist Engineers

On page 930, June 30, an article by John Thorn appeared under the above caption, to which you have taken exception. I quite agree with Mr. Thorn, and venture to say that not many engineers are machinists. If we must be machinists, then why be engineers, when the average wage of the former in this country is 45 to 50c. per hour, and the engineer, with few exceptions, gets 30c. or even less.

Large companies nearly always keep a machinist, and, as Mr. Thorn says, in the plant so small as not to require the service of one, they very seldom have the tools for doing that class of work, so that knowledge of the machinist trade would be of little use to an engineer. There are enough jack-of-all-trades in this country already. When an engineer has thoroughly mastered the

handling of steam machinery in both theory and practice, along with a knowledge of electricity, he has gone far enough; anything outside of this is butting into another man's trade.

I aim to make myself as efficient as I can in the handling of steam and electric machinery by hard study and conscientious work. A fair knowledge of the trades can be gained by reading books and magazines, but to get the practice in each would take a lifetime of apprenticeship, and the victim would die of starvation long before he had finished.

I do not mean that an engineer should not be able to make his own common repairs, for he certainly should, but when it comes to a job requiring mechanical skill and fineness out of our regular line of work, then we should call in that particular tradesman to do it.

N. C. Gleason.

Red Deer, Alta., Canada.

[The two previous articles agree with this that the engineer should "be able to make his own common repairs," and "if required to do this work frequently he will soon acquire a skill equal to a machinist's," and "certain it is that, in either case, doing or supervising, the more positive and accurate the knowledge, the more satisfactory will be the results." See also the second paragraph, beginning with the second sentence, on page 926.—Editor.]

Blowoff Pipe Failures

On page 72, July 14, John Thorn wants to know why the lightning should come down the chimney, strike the blowoff pipe and injure nothing else. In my opinion, the chimney and boiler were large enough to conduct the lightning to the blowoff pipe without their being damaged, but the blowoff pipe was so much smaller that the increased resistance was great enough to melt the pipe.

Willis W. Nelson.

Spokane, Wash.

Automatic Cutoff Engine

The type of governor described by Alfred Butcher, on page 848, June 16, will give good regulation if properly cared for. The chief trouble is in properly lubricating the eccentric hanger-pin bearing. This (and the link bearings) is generally equipped by the engine makers with a hand-compression grease cup, especially unsatisfactory on engines which run almost continually. The reason is that it is practically impossible to exert the necessary pressure on the screw cup to force the grease very far around the pin. This must be done, of course, while the engine is idle. When it is running, the pin merely oscillates and does not turn completely over. The result is that the side of the pin opposite the grease cup gets very little, if any, lubrication, and the pin soon becomes rusty, causing trouble with the regulation and rapid wear.

We have found a way out by the use of spring-compression cups and a light grease. These cups will produce good results because the spring pressure, acting on the grease while the pin is oscillating, will force it around the pin. Before we put spring cups on it was necessary to use a heavy hammer to take the pins out, and the pin was always rusty. Now, when a pin is taken out after an all-winter run, it is as bright and in as good condition as when it was put in. A little practice will enable the operator to select a grease of the proper consistency and to adjust the spring to the right tension.

H. G. Gibson.

Washington, D. C.

A Hot Fire and No Water

At 6:30 a.m., June 11, a boiler failure occurred at the plant of the Crescent Macaroni & Cracker Co., Davenport, Iowa.

The night fireman was preparing to start up the plant for the morning when the gage-glass broke on one of the two boilers connected.

He closed the valves and, after putting in a new glass, so opened or set them that the glass showed three gages of water. Thinking he had too much, he continued to blow the boiler down, as the glass still showed three gages notwithstanding that the safety plug had melted and blown out when the boiler became dry.

Even after the plug blew out, a hot fire was maintained, until the bottom of the boiler bagged about 7 in. The iron stretched until very thin and burst apart, leaving an opening about 2 in. wide. The steam then extinguished the fire.

At the time the boiler burst there was a pressure of 50 lb., although when the glass broke both boilers were carrying 110 lb. They were return-tubular boilers, 60 in. by 18 ft. The boiler setting was not disturbed in the least. One stay rod was pulled apart and the other was stretched until it buckled up among the flues when the boiler was cooled. Both heads were slightly bulged.

W. M. Bartlett.

Davenport, Iowa.

An Interesting Cylinder Failure

This article, on page 60, July 14, brings to mind an accident three years ago on a steamship, equipped with twin-screw engines of the vertical, triple-expansion type. Shortly after leaving port the valve broke on the intermediate cylinder. We took out the broken pieces and ran on the high- and low-pressure cylinders, the intermediate cylinder acting as a receiver. Everything went well for about two days, then, about 3 a.m., a slight groaning noise started in the high-pressure cylinder, and increased so fast that I had to slow down. I examined the rod and it was found perfectly cool.

We had no lubricators or any other way of putting oil in the cylinder, so the only thing left was to make the best speed possible, about one-third, full speed being 185 r.p.m. I reported to my relief, at 6 o'clock, how it had been acting. At 9 o'clock the engine was up to speed again, but about 9:15 the groaning noise became suddenly heavy and the engineer tried to locate the trouble. While he was looking up at the packing gland, the cylinder exploded, making three openings its entire length, and knocking the bottom of the cylinder out, so that it fell down and rested on the crosshead.

It also pushed the rod through the piston, the piston dropping down and resting on the cylinder bottom. One peculiar thing about the explosion was that, aside from

getting dirt in his eye, the engineer was not injured. We found that the piston rings and the cylinder walls were smooth and glossy, therefore, the theory of gripping was eliminated, and we could not find the cause of the groaning, and I have been unable to satisfactorily explain it. The cranks were set 120 deg. apart and were counterbalanced. The valve-gear was the link motion. The pressures were throttle, 125 lb., low-pressure receiver 40 lb., and the vacuum was 25 in.

I would be pleased to hear some theories as to the cause of the groaning and also the explosion.

M. C. MAYNARD.

Charleston, S. C.

Small Air Compressor

Frank Richards criticises on page 927, June 30, a compressor described by me. Realizing that others may be laboring under the same difficulty, I would remind him that air is one of the lightest of gases, water being something like 813½ times its weight. Air is compressible to a great deal less than its normal volume, while water, we know, is practically noncompressible. This is the reason for the difference in the amount of clearance in the water pump and the air compressor. In other words, the difference in the two designs is due to the solidness of water and the compressibility of air. "Tight packing" would not permit of a steam pump being used as an air compressor for pressures exceeding a few pounds, as the piston would only compress the air in the cylinder, and its expansion would again fill the cylinder, while water would be forced through the discharge valves and the return of the piston would draw in another charge.

I will admit that, from a practical standpoint, water as a medium for compressing air has been tried and proved a failure from the standpoint of economy, aside from systems utilizing its gravity, but in case of a small amount being in demand with no other means available, the combination described works quite satisfactorily. It is a regrettable fact that a great number of us are so little versed on the handling of air as compared with the other elements.

FRANK W. HUDSON.

Klamath Falls, Ore.

Oil Explosions in Air Compressors

John J. Oelrich told of an explosion in air pipes on page 72, July 14. This seems to have been a typical occurrence, and although the account is short, all the essential particulars may be gathered from it if we read between the lines.

It seems singular that the pipes could have been so badly knocked to pieces and yet not damage the cylinder. The pipes should be just as strong in proportion to their size as the cylinder. The conclusion must be that there was no explosion in the cylinder. It has frequently happened with single-stage compressors that oily deposits in the cylinder or pipe take fire, and the flame is carried along into the receiver and pipes beyond, with no serious results beyond the excessive heat. After the compressor has been stopped and cooled off, operations may be resumed.

Sometimes, however, as apparently in this case, the combustion is so rapid as to amount to an explosion. It is fortunate that the proportions of oily vapor and of air to form an explosive mixture are narrowly limited; otherwise, these explosions would be more frequent. In gasoline-engine practice, the proportions are confined to narrow limits, but outside these limits either way, the mixture is nonexplosive.

Oil can be limited in compressed air systems so that neither ignition nor explosions will occur. Such occurrences do not come by chance but by invitation, or at least by permission.

A fusible plug will often give timely warning of a possible ignition, or if that should occur, to prevent the more disastrous explosion which might follow. When so warned, it is always best to instantly stop the compressor and the flow of the air.

FRANK RICHARDS.

New York City.

Hints on Starting a Compression Plant

Mr. Anderson's criticism in the July 7 issue of my article in the June 2 issue, was appreciated. The criticism relating to the density of the brine should, as Mr. Anderson pointed out, have read "70 to 90 deg." on the salometer, instead of "70 to 90 Beaumé."

Mr. Anderson does not quite understand me when I say: "All double-acting machines have equalizers; see that they are open when starting." If he will consider the machine he mentions, he will recollect that the equalizing cocks on every one of these machines, single- or double-acting, are on the ammonia cylinders, and one will have a hard time to start such a machine if they are not opened first. It is important to close them when the machine is running, for, if neglected, it will not do the required work. These equalizing cocks are also useful when the compressors are pumped out, as they serve to let oil mixed with ammonia out of the compressor.

I further said: "The water over the condenser should not be turned on until the pressure gages indicate the pressure usually carried. Sometimes I have run a dry-gas machine in cold weather for over half an hour before the gages indicated the pressure we usually carried." I found that I had the system in good working condition much sooner by turning the water over the condenser after the ammonia was turned on.

Our condenser has been in use for the last eighteen years, and is still in good condition. It is very true that the direct-expansion system eliminates brine pumps, tanks, etc., but though more expensive, the brine system for a small plant is more economical and practical than the direct system. The brine system is used in many small plants having only one engineer; the engine is run during the day and shut down during the night while the brine pump is kept running, the refrigerating capacity of the cold brine being enough for the night.

W. L. KEIL.

Philadelphia, Penn.

Engineers' Study Course

Elementary Mechanics--XXI

LAST LESSON'S ANSWERS

91. The area of the piston equals

$$0.7854 \times 9^2 = 63.62 \text{ } sq.in.,$$

and the total pressure on the piston is equal to

$$63.62 \times 35 = 2227 \text{ } lb.$$

The length of the stroke is 12 in., or 1 ft., and, since the engine is double acting (that is, the engine takes steam on both sides of the piston), the piston will travel 2×1 or 2 ft. in one revolution of the engine; and the work done will equal

$$2227 \times 2 = 4454 \text{ } ft.\text{-}lb.$$

NOTE—In an actual engine test, the mean effective steam pressure will generally be different for the head and the crank ends of the cylinder. On the crank end a correction must be made for the area of the piston rod, which will reduce the effective area of the piston.

92. The work done in one revolution was found to be 4454 ft.-lb., and hence the work done in 250 revolutions will equal

$$250 \times 4454 = 1{,}113{,}500 \text{ } ft.\text{-}lb.$$

Since this work was done in 1 min., the horsepower will be

$$hp. = \frac{1{,}113{,}500}{33{,}000} = 33.7+$$

93. The *prony brake* is a device for absorbing the power delivered by an engine, and consists of a series of wooden blocks fastened to a metal strap which passes around the rim of the wheel on which the brake is placed. By drawing together the ends of the strap, pressure may be put on the blocks, the value of which is determined by resting the end of the brake arm on platform scales. In figuring the horsepower developed, it is essential that the *net load* on the brake be used. This net load is found by subtracting the weight of the brake arm from the total load on the platform scales. For the sake of clearness in finding the brake horsepower, assume the wheel as stationary and consider the weight of 120 lb. as rotating. The distance that the weight would travel in one revolution of the engine would equal the circumference of a circle whose radius is equal to the length of the brake arm. Hence the work done in one revolution will equal ($2 \times 3.1416 \times 5$ or) 31.416 ft. times the net weight of 120 lb,

$$31.416 \times 120 = 3770 \text{ } ft.\text{-}lb. \text{ } per \text{ } revolution.$$

(Note—The circumference of a circle equals $2 \times 3.1416 \times$ the radius.)

The work done per minute will be

$$3770 \times 250 = 942{,}500 \text{ } ft.\text{-}lb.$$

and the developed horsepower will be

$$\frac{942{,}500}{33{,}000} = 28.6- \text{ } hp.$$

94. The output is the brake horsepower or 28.6, and the input is the indicated horsepower; that is, the power developed in the engine cylinder. (Note—The term indicated horsepower is used because the average steam pressure is found from a diagram taken with an indicator.)

$$efficiency = \frac{output}{input} = \frac{28.6}{33.7} = 84.8+ \text{ } per \text{ } cent.$$

95. The pressure between the blocks and the face of the pulley causes friction to be generated which is dissipated in the form of heat. To keep the pulley cool it

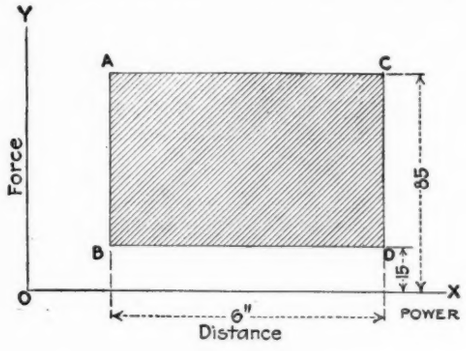


FIG. 67

is necessary to provide means of conducting away the heat generated. This is usually done by circulating water on the inside of a flanged pulley.

The brake or developed horsepower can never be greater than the power developed in the cylinder because friction will always be present in various parts of the engine.

GRAPHICAL REPRESENTATION OF WORK

Work has been defined as the product of a force times a distance. The area of any plane figure is the product of the base times the average height of the figure, and, as work involves but two terms, it may be represented graphically by the area of a figure whose base is proportional to the distance, and whose altitude is equal to the force. Thus, in a direct-acting steam pump, if the pressure on one side of the piston is 85 lb. per sq.in., and on the other side is 15 lb., then the average pressure will equal 70 lb. per sq.in. In Fig. 67 let the distance *BD* represent the stroke of the pump (assumed as 6 in.) and *AB* equal the unbalanced steam pressure. Then the area *ACDBA* will represent the work done by the steam on 1 sq.in. of the piston.

The area

$$ACDBA = AB \times BD = 70 \times 6 = 420 \text{ } in.\text{-}lb. = 35 \text{ } ft.\text{-}lb.$$

If the area of the piston is 20 sq.in., the total work done per stroke of the pump is

$$20 \times 35 = 700 \text{ } ft.\text{-}lb.$$

In like manner the area *ABCDA* of Fig. 68 represents the work done on 1 sq.in. of the piston of the steam engine provided the distance *EF* represents the stroke of the engine and the average height of the figure

is proportional to the mean effective steam pressure in the engine cylinder. The average height of such a figure as shown may be found by dividing the diagram into 10 or more parts and finding the average height of each separate part, or it may be found more readily by the aid of an instrument called the planimeter.

As a general rule, the mean effective steam pressure will be found from the indicator diagram (Fig. 68) and the indicated horsepower of the engine may be found from the equation,

$$i.\,hp. = \frac{P_e L A N}{33{,}000} \tag{54}$$

where

P_e = the mean effective steam pressure in pounds per square inch,
L = the length of the stroke in feet,
A = the area of the piston in square inches, and
N = the number of working strokes per minute.

In like manner, the developed or brake horsepower is expressed by the equation

$$b.hp. = \frac{2\pi L N W}{33{,}000} \tag{55}$$

where

L = the length of the brake arm in feet,
N = the number of revolutions per minute,
W = the net load on the brake in pounds, and
π = 3.1416.

Energy

Energy is the capacity of a body for doing work. Any moving body possesses a certain amount of energy which may be transformed into useful work as the body is brought to rest. Thus a stream of water issuing against the bucket of a water wheel has its energy converted into useful work by overcoming the resistance offered by the bucket. The sources of energy are almost unlimited; thus there is energy stored in coal and in all forms of liquid fuels; energy is stored in a coiled spring; the steam in a boiler possesses energy, and the human being has various forms of muscular energy.

Energy may be divided into two general classes,

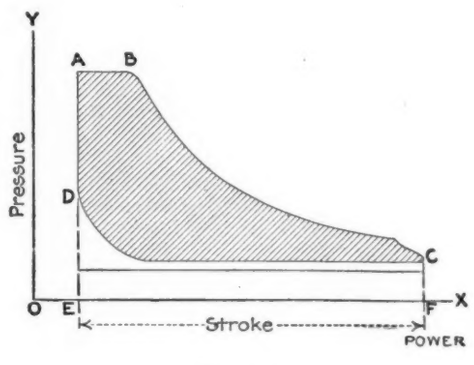


Fig. 68

(1) *Potential,* or energy of position, and

(2) *Kinetic,* or energy of motion.

The water in a reservoir has potential energy due to its location above a certain level. Energy was required to place the water at this level. The amount of potential energy in a body depends upon its weight and the distance of the body above a given reference line or plane. Thus, if an object weighing W pounds be located at a distance of H feet above a given datum plane, then the potential energy of the body will be expressed by the equation,

$$K = W \times H \tag{56}$$

The unit of energy is the same as that used for work, namely, the foot-pound.

An object possesses kinetic energy by virtue of its velocity. A bullet shot from a rifle is brought to rest by meeting with a body which offers a resistance to the motion of the bullet. The work done by the bullet is equal to the product of the resistance overcome and the distance the bullet penetrated the object, and if frictional losses be neglected the work done by the bullet must equal the kinetic energy of the bullet.

In equation (49) it was shown that the force required to give a definite acceleration to a body weighing W pounds was equal to $\frac{W}{g} \times a$, and from equation (33) the acceleration was found to be $\frac{V^2}{2S}$ therefore, since

$$F = \frac{W}{g} \times a$$

and

$$a = \frac{V^2}{2S}$$

it follows that

$$F = \frac{W}{g} \times \frac{V^2}{2S}$$

or

$$F \times S = \frac{W V^2}{2g} \tag{57}$$

But $F \times S$ is the product of a force times a distance, and hence represents the work done in bringing the body to rest. The term $\frac{W V^2}{2g}$ represents the energy stored in the body due to its velocity and is therefore the kinetic energy of the body.

Let

K_e = the kinetic energy in foot-pounds,
V = the velocity of the body in feet per second,
W = the weight of the body in pounds, then

$$K_e = \frac{W V^2}{2g} \tag{58}$$

Study Questions

96. A pump delivers 1000 gal. of water per minute against a pressure of 120 lb. per sq.in. Find the horsepower required.

97. If the efficiency between the steam and water ends of the pump is 70 per cent., find the power required in the steam cylinder.

98. Find the horsepower of an engine that raises 20 tons of coal per hour from a barge to a coal bunker located 150 ft. above the barge, assuming the efficiency between the engine and the load as 75 per cent.

99. A weight of 1000 lb. is used for crushing old castings. If the weight be raised to a distance of 95 ft. above the casting, find the potential energy of the weight.

100. Find the kinetic energy of the weight the instant it touches the casting, assuming that the weight was allowed to fall freely.

Balancing of Internal-Combustion Engines*

By H. F. FULLAGAR

Balancing internal-combustion engines is in general more difficult than with steam engines. The single-acting cylinder and trunk piston generally necessitate wider crank angles than with steam, and if a larger number of cylinders are employed, vibration arises owing to the increased length and flexibility of the crank case or framing. A further difficulty is from the sudden and violent increase of pressure when the charge is fired by a spark, or, when fired by high compression, the compression stroke produces a severe reversal of torque in the crankshaft and reversal of side-thrust between the piston or crosshead and its guide.

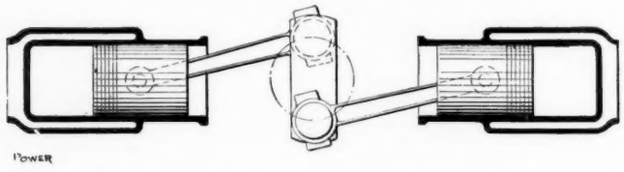


FIG. 1. OPPOSED CYLINDERS WITH PERFECT BALANCE OF MASS

BALANCE OF MASS

Balance of the rotating members, the crankshaft and camshaft presents, of course, no theoretical difficulty, provided the crank case is sufficiently rigid to resist the reactions set up.

The inertia forces of the reciprocating parts are of two kinds; primary forces, such as would result if the connecting-rod were of infinite length; and secondary forces, due to the additional motion from the finite length of the connecting-rod. This secondary motion is almost simple harmonic in character, but it has double the frequency. Perfect balance of both the primary and secondary forces can, together, be secured only by placing the connecting-rods on opposite sides of the crankshaft, as in Fig. 1. If, as usual, the crankshaft revolves, the connecting-rods must be attached to opposite cranks, but, if the cylinders revolve both connecting-rods can be attached to a single crank. These constructions, however, have but limited application.

The ordinary motor-car engine with four cylinders operating upon the four-stroke cycle has its cranks in one plane, 180 deg. apart, in order to give reasonable uniformity of impulse. In this case the secondary forces are wholly unbalanced. When the plane of the cranks is horizontal, the connecting-rod has moved the piston to below midstroke by the amount a, Fig. 2, which, if the length of the connecting-rod be four times the crank radius, amounts to one-sixteenth of the stroke. As this displacement occurs twice per revolution and affects all four pistons, the secondary forces set up are equivalent to the inertia of a single piston moving the whole stroke, but acting with double the frequency. With a connecting-rod the length of five cranks, the secondary inertia force is four-fifths of this amount. When two such sets of four cylinders are placed together in the V-type engine, the secondary forces of each set are unbalanced, and their resultant is 40 per cent. greater than either and acts in a horizontal plane.

The secondary forces of the four-cylinder engine, Fig. 2, result from the fact that the common center of gravity of the four pistons, instead of being stationary, as would be the case if the connecting-rods were infinitely long, has a small harmonic motion of double frequency. It can, therefore, be balanced by reciprocating or rotating balance-weights, driven at twice the frequency of the main piston. One method is to gear a pair of wheels carrying balance-weights to the main crankshaft, which drives them at double its speed. As the wheels rotate in opposite directions, the components of the centrifugal forces of the weights always balance themselves in the plane through the axis of the wheels, but have a vertical component which balances the secondary inertia forces. This method, however, involves calling into play two otherwise useless forces, with some addition to the weight and number of parts.

With four cylinders operating upon the two-stroke cycle, the cranks can be placed at right angles instead of at 180 deg., and it is then possible to secure complete balance of both primary and secondary forces, with the exception of a couple produced by the secondary forces in the plane of the cylinders and crankshaft, which tends to rock the engine in a fore-and-aft direction. This couple can usually be neglected in practical application. Engines with five and six cylinders in line, with either cycle, can be perfectly balanced as to the primary, and almost perfectly as to the secondary inertia forces.

To sum up, therefore, the only engine constructions in common use in which balance of mass is completely, or almost completely, secured by the neutralization of the primary and secondary inertia forces, are the engine with rotating cylinders, the engine with five or six cylinders in line, and the four-cylinder, two-stroke-cycle engine with cranks at right angles. All these engines will be without vibration when driven by an external source, provided the crank case or framing is itself perfectly rigid. In practice, it is not always possible, if the engine is long, to obtain sufficient rigidity. With the light motor-car type, even if the crank case be sufficiently rigid, it is difficult when the crankshaft is long to make it so stiff that the engine will not tend to vibrate relative to its flywheel, whose mass-center remains almost stationary.

BALANCE OF IMPULSE

Balance of mass is insufficient in itself to produce a vibrationless engine, because it takes no account of the violently fluctuating pressures in the cylinders, and the consequent strains in the crankshaft and engine framing. To secure freedom from vibration, it is necessary so to arrange the cylinders in relation to the crankshaft that strains in the frame are either eliminated or so balance each other as to have no tendency to shift the center of gravity of the engine relative to its crankshaft and point of support.

If the cylinders, Fig. 1, are arranged in line and fire simultaneously with exactly equal charges, there will be no tendency for the engine to move except, of course, to rotate around the crankshaft. The Junkers engine obtains this equality of impulse, but is unbalanced as to the secondary mass forces. The three cranks of each cylinder receive simultaneous impulses once only per revolution. The crankshaft of the two-cylinder engine, therefore, receives virtually one impulse for every half-revolution. It will be seen, moreover, that in this, as in all single-acting engines, the pressures on the pistons during the compression and explosion strokes twist the crankshaft first backward and then forward, producing a severe condition of stress, while the reaction of the crossheads on their guides also alternate in sign with each stroke.

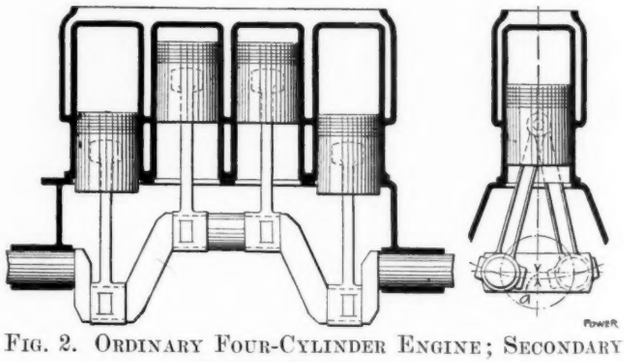


FIG. 2. ORDINARY FOUR-CYLINDER ENGINE; SECONDARY FORCES UNBALANCED

If, however, a second pair of cylinders, each with a pair of pistons, be arranged tandem on the top of the first two each tandem line is then double-acting and the cranks of the two sets can consequently be placed at right angles, when balance of impulse will be obtained with primary and secondary mass balance, except only as regards the rocking secondary couple in the principal plane of the engine. The torque transmitted to the crankshaft and the reactions of the crossheads on their guides will then also be in one di-

*From a paper presented at the July meeting of the Institution of Mechanical Engineers in Paris.

rection only. This arrangement, however, involves great height and a large number of parts, together with an expensive form of crankshaft, and the same results are obtained more simply, and without these objections in the author's arrangement, Fig. 3.

In this, two open-ended cylinders, each with a pair of opposed pistons, are placed closely together side by side, and the upper piston of one cylinder is connected to the lower piston of the other by a pair of external oblique tie-rods, as shown, the piston A to the piston D, and the piston C to the piston B. An explosion between A and B drives B down and A up, drawing up D by the oblique rods and giving two equal and opposite impulses to the two cranks. In separating, the pistons A and B draw together the pistons C and D, compressing the charge between them. The engine operates upon the two-stroke cycle, the pistons at the ends of their stroke uncovering the inlet and exhaust ports, as in the original Oechelhäuser arrangement.

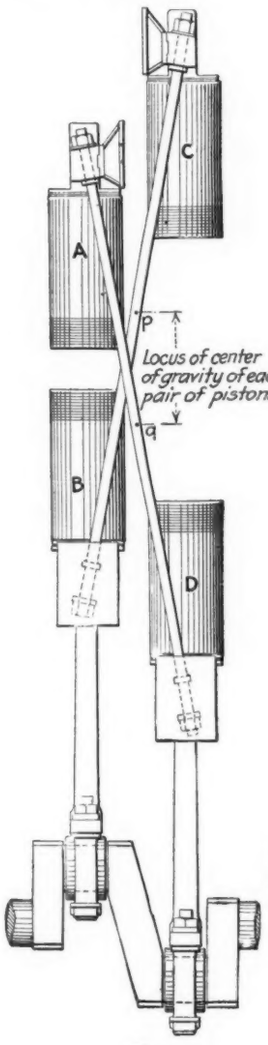


FIG. 3

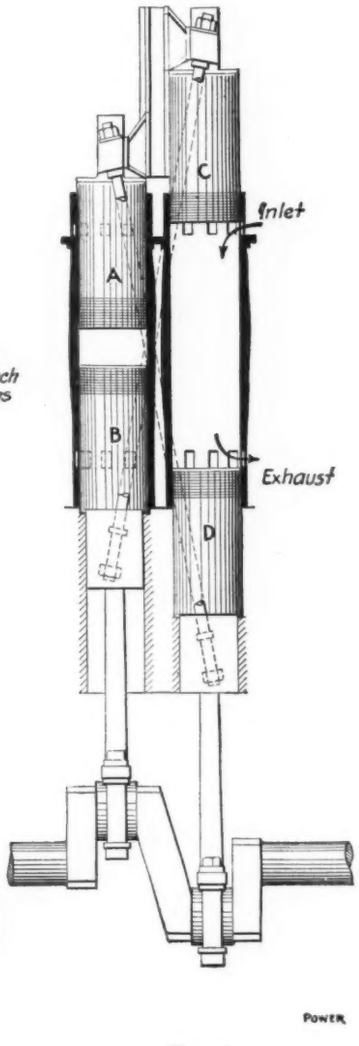


FIG. 4

FIG. 3. SHOWING COMPLETE PRIMARY BALANCE. FIG. 4. FULLAGAR ENGINE WITH PRIMARY AND SECONDARY BALANCE OF MASS, AND BALANCE OF IMPULSE IF MADE WITH FOUR CYLINDERS

The complete engine has two such pairs of cylinders and a second pair of cranks at right angles to the first. The explosions in the four cylinders, acting upon the eight pistons, produce eight impulses per revolution which are transmitted to the crankshaft in equal pairs. The vertical forces at all times balance each other, and, as in the Junkers engine, are not transmitted through the engine frame.

On referring to Fig. 4, it will be seen that the pistons of each pair are rigidly joined together and form one moving part. The center of gravity of the pistons A and D (Fig. 3) is at a point q, and travels up and down on the line pq, while the center of gravity of the other pair of connected pistons C and B is at the point p and travels up and down the same line. Thus the primary forces are perfectly balanced.

Secondary forces result from the fact that the common center of gravity of all four pistons and their connecting-rods oscillates on the line pq. This force is, however, balanced by the corresponding force in the other pair of cylinders which oscillate in the opposite phase, and as the two pairs of cylinders are brought closely together, the secondary couple, which alone remains, is much smaller than in the Junkers arrangement. With a six-cylinder engine even this secondary couple is entirely obliterated.

A 500-hp. engine of this type has been in operation about a year. At first sight, it might be supposed that the oblique rods would involve considerable friction, but the angle of the rods is less than the maximum angle of the connecting-rods, and this friction is actually less than would be the case if each of the eight pistons had its own crank and connecting-rod. The mechanical efficiency, excluding the air and gas pumps, is over 90 per cent.

Utility Experts Appointed

Philadelphia's convention next November of mayors and municipal officials throughout the country for the establishment of a Utilities Bureau to represent the cities of the nation in working out their relations with public utility corporations, promises to be one of the most notable conventions for municipal advancement ever held in the United States. With the approval of his coworkers, including the mayors of New York, Chicago, Cleveland and other cities, Mayor Blankenburg of Philadelphia appointed the following preliminary committee of experts to work out the details of the convention:

Louis D. Brandeis, lawyer, Boston; counsel for Interstate Commerce Commission on application of Eastern railroads for 5 per cent. increase; Charles R. VanHise, president, University of Wisconsin, Madison, Wis.; S. S. Fels, manufacturer, Philadelphia; Frederick W. Taylor, consulting engineer, Philadelphia, past president of the American Society of Mechanical Engineers, leader in scientific management movement; Frederick A. Cleveland, director of the New York Bureau of Municipal Research, formerly chairman of the President's Commission on Economy and Efficiency; Leo S. Rowe, professor of political science, University of Pennsylvania, president of the American Academy of Political and Social Science; Charles F. Jenkins, publisher, Philadelphia, proprietor of the "Farm Journal"; Felix Frankfurter, administrator and lawyer, Cambridge, Mass., professor of law, Harvard University, chief legal adviser of the Colonial Administration of the United States under Presidents Roosevelt, Taft and Wilson, had important part in trials of Morse, Heinze and the Sugar Trust.

Mayor Blankenburg, it was said, will increase the membership by three or more experts. The Utilities Bureau, Director Cooke said, is now ready for business. Such temporary administrative staff as may be needed to carry on its work between now and next November, when the conference of mayors will be held here, has now been provided. In addition to gathering general data, other cities will be advised, he said, and assisted in making such application of its researches to local conditions as shall be most likely to secure favorable consideration at the hands of Public Service Commissions and other like bodies.

Coal Breaks All Records

The production of coal in the United States has again broken all previous records, the output for 1913 being 570,048,125 short tons, which is considerably more than double the production of 1900 and more than eight times the production of 1880, according to a statement just issued by the United States Geological Survey, from figures compiled by Edward W. Parker, coal statistician. The value of the coal mined in 1913 is given as $760,488,785.

Compared with the previous year the output for 1913 shows an increase of 35,581,545 tons, or nearly 7 per cent. The increased activity indicated by these figures was well distributed throughout the 29 coal-producing States, 23 of which showed increases and only 6 decreased production, the decrease in one of these—Colorado—being due solely to labor trouble. Of those showing increase, 12 made record yields, and Pennsylvania, the leading coal State, broke records in both bituminous and anthracite production. The States which broke all former records in coal production were Alabama, Illinois, Kentucky,

Montana, New Mexico, Ohio, Oklahoma, Pennsylvania, Texas, Utah, Virginia and West Virginia. The largest increase in the production of bituminous coal was in Pennsylvania, where 11,915,729 tons was added to the output of 1912. West Virginia showed the second largest gain, 4,522,295 tons, and Kentucky the third largest gain, 3,126,079 tons, which was also the largest percentage of increase, amounting to 19 per cent., of all the important coal-producing States. Indiana was fourth, Illinois fifth, Ohio sixth, and Alabama seventh. While the total increase was very large as figured in tons, the percentage is what may be considered normal and indicative of healthy industrial activity throughout the country.

ENGINEERING AFFAIRS

On the evening of July 21 the University of Pittsburg gave a dinner for the professors of engineering of the different colleges of the country who are in Pittsburgh for the summer course given by the Westinghouse Electric & Manufacturing Co. An address by Dean F. L. Bishop, of the School of Engineering of the University of Pittsburgh, had the topic, "The Pittsburgh Idea" in education. Each of the visiting professors was called upon to give a short boost to his own particular college. Fourteen different colleges and universities were represented.

PERSONALS

Hubert E. Collins, consulting and operating engineer, has opened an office at 132 Boyce Ave., Utica.

William Schatz is now representing the Platt & Washburn Refining Company, 11 Broadway, New York City.

R. A. Anderson has been appointed chief engineer of the power station of the Portsmouth (N H.) Electric Railway, to succeed John Kirk.

H. E. Harley has been appointed chief engineer of the power station of the Jacksonville (Fla.) Traction Co., to succeed F. D. Barry.

Lester Boring, formerly chief plant engineer, has been appointed superintendent of the municipal electric and water plant at Tipton, Ind.

W. B. Gregory was recently appointed engineer of the power station of the Connecticut Co. at Berlin, Conn., on the Middletown branch, to succeed S. Sargeant.

W. R. Haynie, who has been for over two years United States representative for Usines Carels Freres, of Ghent, Belgium, having contracted with the Nordberg Manufacturing Co. for the exclusive manufacturing and selling rights on Carels-Diesel engines in the United States, is now the special Diesel representative of the Nordberg Manufacturing Co., with offices at 30 Church Street, N. Y.

Edward Gray for some time mechanical engineer of the Ford Motor Co. and well known in gas power circles, especially in connection with the design and installation of the big Ford gas engine, has severed his connections with that company and will for the present devote his time to some personal projects which he has now under way in Detroit. His successor at the Ford Co. will be William B. Mayo, formerly secretary and general manager of the Hooven, Owens, Rentschler Co.

Edward Schildhauer resigned as electrical and mechanical engineer on July 13 from the Panama Canal service. He entered the service as electrical and mechanical engineer in 1906. He has been occupied principally with the designing, manufacturing, and installation, under the direction of Col. H. F. Hodges, engineer of maintenance, of the machinery and electrical equipment for the operation of the Canal locks, spillways and power plants, including the new hydroelectric station at Gatun, the substations at Gatun, Cristobal, Miraflores and Balboa, and with the new transisthmian transmission line. He invented and patented the bull wheel which operates the lock gates, and the system of electric towing locomotives for handling ships in the locks. Another novel device manufactured from designs prepared in his office, is the system of remote control by which every part of the lock operating machinery is manipulated from a central station or control house, and where, with the aid of a reproduction of the lock and its operating features in miniature, every movement is registered before the eyes of the operator. Mr. Schildhauer was born in New Holstein, Wis., entered the University of Wisconsin at the age of 21, and was graduated in 1897, with the degree of bachelor of science in electrical engineering. The master's degree was conferred in 1911. He was engaged in electric railway construction uneil 1898, when he entered the employ of the Chicago Edison Co. and was with this company at the time of his appointment to the Canal service. He is president of the Panama Section of the American Institute of Electrical Engineers, chairman of the Canal Zone Chapter of the American National Red Cross Society and a member of various societies in the United States, including the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the National Electric Light Association and the American Electro-Chemical Society. He will make his headquarters at the Engineers' Club, New York City. He was given a farewell reception by the Tivoli Club July 11 and by the University Club on July 15.

OBITUARY

EDWARD B. DENNY

On July 12, Edward B. Denny, past president of the National Association of Master Steam and Hot Water Fitters, died at his home in Newark, N. J. His death was due to heart disease superinduced by acute indigestion.

Mr. Denny received a common-school education and, after several years' employment in other lines, took up the business of manufacturing gas machines in 1874. He invented a portable gasolene gas machine, and about the same time he enlarged his field of operations by taking up the steam and hot water heating business, in which line he has been engaged ever since in partnership with brothers.

He was one of five children whose average at the time of his death was over 60 years.

Mr. Denny was a member of the American Society of Heating and Ventilating Engineers; National Association of Master Steam and Hot Water Fitters; New Jersey State Association of Master Steam and Hot Water Fitters; Newark Association of Master Steam and Hot Water Fitters; Newark Y. M. C. A.; St. John's Lodge, No. 1, F. & A. M., Newark, N. J.; and Empire State Society of the Sons of the American Revolution.

The Rev. Dr. John McDowell of Park Presbyterian Church conducted the funeral services at the home of John W. Denny, Newark, N. J. Interment was on Thursday morning, July 16, at Linden Cemetery, near Elizabeth, N. J.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Holyoke Street Ry. Co., Holyoke, Mass., has purchased a site on Pleasant St., in Mill Valley, on which to build a power house to supply energy for the Sunderland and Amherst division. Louis D. Pelissier is Gen. Mgr.

The Narragansett Electric Lighting Co., Providence, R. I., contemplates rebuilding the turbine room of its generating station some time within the next few months. W. T. Oviatt is Gen. Supt.

The power house at the plant of the Farist Steel Co., 137 East Main St., Bridgeport, Conn., will be rebuilt. The building will be of brick and steel, 55x78 ft.

Bids will be received until 3 p.m., Aug. 17, by the State Hospital Commission, Albany, N. Y., for the construction of a power house, boilers, equipment and steam conduit, plumbing, electric equipment and underground electric conduit at the Long Island State Hospital, Brooklyn, N. Y. J. H. Hanify is Secy. State Hospital Comn.

The Lebanon Power & Lighting Co., Canaan, N. Y., plans to build a power plant in Canaan, on the outlet of Queechy Lake, to supply energy to Canaan, New Lebanon, Lebanon Springs and West Lebanon. The equipment of the plant will include: One 225-hp. Atlas boiler, one 175-hp. Corliss engine, two Leffel waterwheels (135 hp.), one 150-kw. General Electric and one 125-kw. Fort Wayne generator (each three-phase, 60-cycle, 2300-volts), General Electric switchboard equipment and Duncan transformers. O. C. Schmoyer, Greenville, Penn., is Engr.-in-Charge.

It is reported that the power plant for the Onondaga County Tuberculosis Sanitarium, Syracuse, N. Y., will cost about $35,000. The equipment will include boilers, engines, heating apparatus, pumps, telephone switchboard, etc.

The City Council has authorized Samuel J. Mason, City Engr., to prepare an estimate of the cost of installing a municipal electric-light plant in Perth Amboy, N. J.

Bids are being received by John T. Windrim, Arch., Commonwealth Bldg., Philadelphia, for the construction of a one-story brick and concrete power house at 20th St. and Oregon Ave., Philadelphia, Penn., for the Stephen Girard Estate. It will be 67x88 ft.